THE ENGINEER OFFICERS' CONFERENCE, 1974

The Royal Naval Engineer Officers' Conference was held in the theatre at the R.N.E.C., Manadon, on 25th April 1974. The general theme of the conference was Fleet Support.

After those attending had been welcomed by Captain Pillar, Vice-Admiral Sir George Raper, K.C.B., the Chief Naval Engineer Officer, opened the conference by saying that he was sorry that a Board meeting had prevented the Chief of Fleet Support, Vice-Admiral Sir Allan Trewby, K.C.B., from being present at the start and hoped that he would be able to be there in time to make some closing remarks.

Admiral Raper went on to say that the attention paid to Fleet Support had increased enormously since we first introduced planned maintenance and thus had a task which was thought to be calculable. There had followed the establishment of Fleet Maintenance Groups, the concept of Fleet Maintenance Bases, ideas of Class Standard Defect Lists and typed Dockyards: the work package concept and its implementation in Polaris submarines had shown what could be done by meticulous planning in working to a time and cost. There had also been the introduction of design for upkeep and an attempt to devise codes of practice for this, and the enormous enhancement of drawing office effort for new ships to provide proper identification of everything in the ships and proper documentation of the support activities. All these had been rapidly developing policies, mostly costing money. The feed back, SUIS, had therefore had to be developed so that we would have a better idea of what was really happening in ships in the field of operational availability of systems, machinery and equipment. Because all this was expensive in terms of manpower in the drawing office for new ships, staff for evaluation, capital cost of base facilities and so on, people would certainly ask whether it was worth it.

Admiral Raper said that his own particular concern was that we should use properly the tools which will now be put into people's hands and take advantage of the possibility in new classes of optimizing availability. He also said that the example of SSBN work package for refits being adjusted by doing more or less work at Faslane during maintenance periods was one which he believed should be seriously considered for our future surface ships.

INTRODUCTION

The printed papers are condensed versions of the original papers prepared for verbal presentation at the conference with Vugraph support and have also had confidential matter excluded. As a result some have certain shortcomings. Some diagrams have been reproduced where this has been found to be necessary.

The papers are followed by edited versions of the main points raised at the discussion periods.

SUPPORT POLICY AND ORGANIZATION: RECENT MAIN DEVELOPMENTS

Captain Bartlett, Director of Fleet Maintenance, opened by saying that just as in biology the survival of a species depends on its ability to adapt to changes in environment so the Royal Navy must keep a careful watch on the changing environment in which support acts and adapt accordingly. This paper takes a look at the changing environment and reviews the responses being made in the support field to adapt to it.

Changes to which Support must adapt

Deployment of the Fleet

Since the decision was taken to withdraw from the Far East and to commit the Royal Navy to NATO, the changes in deployment of warships has been considerable and further changes are probable. The changes are just as dramatic when one considers the number of overseas dockyards and maintenance bases that have been closed.

The consequences for support can be considered as a change in emphasis from world-wide support from a number of overseas bases towards the narrow-seas sortie-type of operation. For such, it becomes economical for the ships to carry less support capability and instead to place increased reliance upon shore-based support within the United Kingdom. This development will become more marked as later classes of ships are brought into service. Already the *Amazon* Class frigates have been designed with a reduced complement and plans have been made to provide them with enhanced level of Fleet Maintenance Group support.

Increased reliance on shore support obviously affects the amount of spares carried and the depth of repair facilities provided on board, and it also raises questions concerning the balance between uniformed and civilian support.

Changes in the Make-up of the Fleet

Aircraft Carriers

As well as changes in deployment patterns, there are obvious changes in the make-up of the Fleet. The most notable of these is the phasing out of the large aircraft carriers and the changed emphasis towards flotillas of small, complex ships carrying a distributed helicopter fleet. Thus the consequence has not been the reduced importance of the Fleet Air Arm which many forecast. Now practically every ship has its own helicopter, new challenges are posed to the aircraft maintainers, and to the maintainers and operators of the host ships' systems.

Submarines

The steadily increasing importance to the Fleet of its submarines is shown by the fact that expenditure on submarines expressed as a percentage of the total expenditure on Naval General Purpose Combat Forces has more than doubled in the last eight years.

Cost Considerations and their Significance

Costs have been rising for centuries, but what is new is the accelerating rate at which weapon costs are now rising. A recent long range naval study showed that in costs per ton displacement the real cost of frigates of comparable size has roughly doubled in eighteen years. In terms of equipments and systems, the acceleration is however more extreme.

If ships and equipments cost more and the Navy is on a declining budget, inevitably there will be less ships. Great endeavours have been made to improve the teeth/tail ratio, but the outcome is still adverse declining from 6:5 to 5:6—an appreciable change in the wrong direction within a period of five years.

One means of offsetting this is to reduce the share of the tail spent on support. Various methods of achieving this are under way; these can be looked at under their long, medium and short term implications. In the long term design for support can be improved; in the mid term support resources and practices can be improved; in the short term better use can be made of existing support resources.

Support Responses in the Long Term

Improved Ship and Equipment Design for Upkeep

The design process is controlled by the Naval Staff Requirements procedure. To make this more sensitive to support needs, its code of practice was recently amended so that the availability, reliability and maintainability clauses are made more detailed and supported by numeric specifications. This will allow better trade off between time, cost, performance and design for support.

The maintainability clause is supported by the Staff Maintenance Requirement No. 1 which in turn is detailed for weapons equipment by Naval Weapons Specification No. 9, and for ship equipment by MANDUS (Management of Design for Upkeep and Support).

Reliability is supported through developments in the field of reliability engineering which include the preparation of manuals for designers and contractors, and sponsorship of university courses under the guidance of the Navy Department Reliability Committee.

Whole Life Cycle Management

To match the effort in ship and equipment design and particularly to capitalize on the potential of the upkeep by exchange policy, much thought is going into the developing of whole life cycle management. This inter-departmental process requires tight organization and the careful balancing of costs incurred by design, supply, repair and maintenance. The specific actions in hand include the development of accounting methods needed for life cycle costing linked to SUIS and other information systems, development of accounting in fleet bases and better forecasts of spares requirements. Mathematical modelling and computer-based simulations are playing an increasing role, and a particular application is in the gas turbine exchange field where the needs of an increasing number of competitors compete for shared manufacturing and repair capacity.

Upkeep by Exchange

This policy, with properly designed removal routes, will give greater flexibility in the planning of maintenance, repair, and refits. However, it must be stressed that a quick change service needs great care to ensure that repairs are undertaken in the most cost-effective manner.

Collaborative Developments

These are developments over which we have less direct control but which offer other advantages. In the last ten years, the number of equipments developed outside the MOD(N) in collaboration with other services and other countries has risen considerably. For example, nationally, the Army now looks after all motor transport and there is a well-established division between the R.A.F. and the Navy for the responsibility for fixed and rotary wing aircraft. All equipments which have an application to more than one of the services are now considered for single management and the number of such items will increase.

The proportion of collaborative ventures with foreign powers has almost doubled over ten years. Thus we are buying surface-to-surface missile systems from the French, while we are are selling them gas turbine propulsion systems. Examples in the aircraft field are the Anglo-French Lynx helicopter and the Anglo-German-Italian multi-role combat aircraft. These projects allow us to develop common support facilities and enable us to buy equipment which we might not otherwise be able to afford.

Support Responses in the Mid Term

Planned Maintenance Refinement (Mardex)

This exercise was based on feedback from the Fleet. The result was a reduction of the planned man-hours spent by ships' staff amounting to half the servicing task and one fifth of the planned maintenance task.

Upkeep Evaluation

Upkeep activities on new equipments are carefully observed and are recorded by elapsed-time photography and video tape recording. Analysis of the results leads to improvements to design, spares support, overhaul and maintenance procedures and support documentation. Significant improvements have been achieved for the new cruiser from evaluations carried out on the Valenta diesel and the main gearbox.

Extension of Intervals between Dockings and Refits

These are aimed at reducing the dockyard load and increasing ship availability. The planned refit intervals for several classes of ships have been extended over the past two years, and newer classes of ships are being designed for a four-year interval.

Non-Destructive Testing (NDT)

There are a number of promising techniques being developed, including underwater television cameras, spectrometric examination of oil, and ultrasonic thickness measurement. Some techniques already in service are being extended through, for example, the building up of the Fleet Vibration Analysis Team. New techniques usually require special kits and training, and some require facilities to be designed into the equipment to enable the testing to be carried out. The techniques are, of course, complementary to professional judgement and performance testing.

Support Responses in the Short Term

Pressure to cut support resources is great and these pressures require careful balancing to ensure that one man's savings do not become another man's disaster. It is essential that all support activities are monitored to ensure that a true balance is kept. Two control activities that have an immediate effect are worthy of mention as they seek to balance limited resources between competing tasks:

Dockyard Loading. The Dockyard Resource Allocation Control is being introduced, details of which will be given in the paper to be read by Admiral Griffin.

Material Shortages. In the stores field, the results of a recent national emergency together with the long-term consequences of world shortages of raw materials are being felt. The effects of an increasingly severe stock-out of wide ranges of materials have already been felt and, as these work through the manufacturing process, they are expected to reflect in items of equipment. To handle this, the Naval Emergency Spares Committee formed from Fleet and Naval Staffs and HQ authorities has been set up. This committee produces information on shortages, sorts out the priorities and devises measures to make the best of the available resources.

Summary

Captain Bartlett concluded by saying that his paper had given a brief outline of trends and some of the changes that are being made to cope with them. Pressures are severe and considerable effort and co-operation is required from all concerned if the best use is to be made of the large resources that are still available to the Royal Navy.

GAS TURBINE SUPPORT FOR NEW DESIGN SHIPS

The Operational Implications Associated with Fuel Economy and Engine Life

Commander Laslett, Head of the Type 22 Frigate Section of the Ship Department, opened by saying that, in the new COGOG ships now entering service with the Royal Navy, the operational usage of the engines is a vital factor affecting the support logistics.

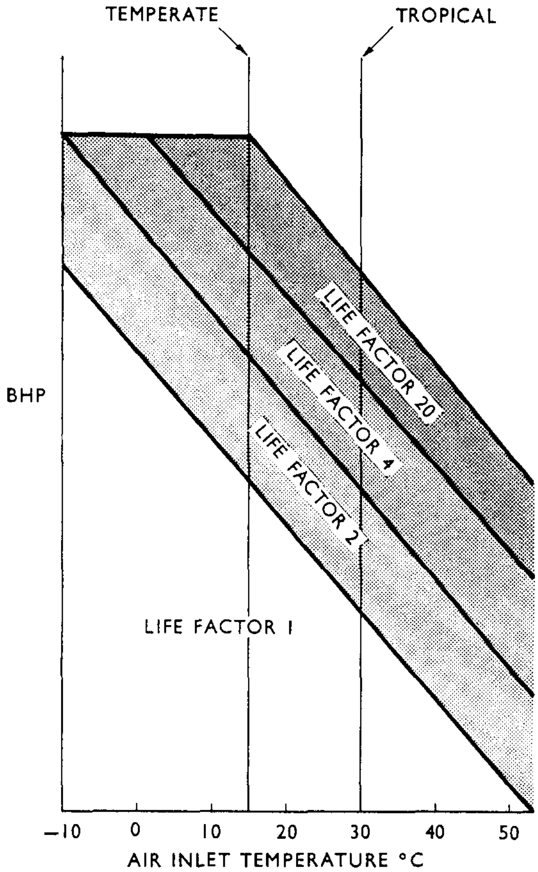


FIG. 1—OLYMPUS TM3B CHANGE OF POWER WITH AIR INTAKE TEMPERATURE SHOWING LIFE FACTOR BANDS

The gas turbine change unit (GTCU) consisting of the gas generator section of the engine for Olympus and the gas generator and the power turbine for Tyne, requires to be replaced either after achieving a pre-determined number of effective running hours or when random failure occurs. This pre-determined period measured in effective running hours is known as the declared overhaul life (DOL). In terms of actual running hours, the time taken to reach DOL is directly influenced by the powers at which the engine has run; the operational implications are obvious.

Declared Overhaul Life (DOL)

It is known that certain components of the engine have a shorter life when run at higher temperatures (higher powers). To allow for this when calculating the effective hours run, multiplication factors greater than unity known as Life Factors are applied to the actual numbers of hours run in certain power bands. Special meters (engine life recorders) are fitted to record the actual hours run in these power bands. The DOL is also effected by the number of starts that the engine has had to endure and a correction factor is applied to allow for this also.

For the Olympus TM3B:

Effective Running Hours $= 20A + 4B + 2C + D + 0{\cdot}5S$

where A, B, C, and D are the actual number of hours that the Olympus has run at Life Factors 20, 4, 2, and 1 respectively and S is the number of starts that the engine has made.

For the Tyne RM1A:

Effective Running Hours = 2E + F + 0·5S
where E and F are the actual number of hours that the Tyne has run at Life Factors 2 and 1 respectively and S is the same as for Olympus.

Life Factor Power Bands

The power bands at which various Life Factors are applied have been published in a confidential DCI. These bands are affected by ambient temperature as shown for the Olympus TM3B in FIG. 1. As an example, the effect of Life Factors on engine life are such that a passage at near full speed would consume about ten times as many effective engine hours as a similar passage made at a speed one and a half knots slower.

Fuel Economy

The interaction between engine life conservation, fuel economy and speed is shown in FIGS. 2 and 3 in which the life factor power bands are superimposed on a typical endurance/speed plot and on a cumulative percentage time underway/speed plot for a COGOG ship (The latter shows the percentage time spent at or below the indicated speed). These plots show that the use of the Tyne engines in the life factor 2 band coincides with the range of speeds in which it is anticipated that the ship will do its greatest percentage of time underway; and that to avoid using the Tyne engines at life factor 2 by using the Olympus instead would result in almost doubling the fuel consumption.

There are ways by which the problem may be alleviated: single shaft running on either Tyne or Olympus, or passages made up of sprints on Olympus and periods on Tynes (mixed running) may prove beneficial but will require careful planning by the Marine Engineer Officer and the Command.

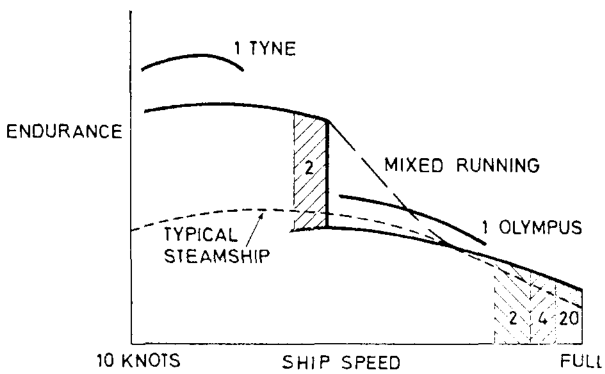


FIG. 2—TYNE AND OLYMPUS LIFE FACTOR BANDS SUPERIMPOSED ON A TYPICAL ENDURANCE/SPEED PLOT FOR A COGOG SHIP

Ship Speed Usage

Actual plots of ship speed usage from the SMA's records of the *Leander* Class indicate wide variations between individual ships. Such differences applied to COGOG ships will result in corresponding variations in the split between Olympus and Tyne usage; and so will upset the support planning which, to ensure that adequate numbers of GTCUs remain in the repair and provisioning pipe line, has been based on a split of 55 per cent. Tyne and 45 per cent. Olympus usage. Including an allowance for random failures, this on average is expected to result in two changes each of Olympus and Tyne GTCUs per year for the first five years of the ships life.

Although the planned split of engine usage has been based on the assumption that the Olympus will be used for confined waters, entering and leaving harbour, and A/S exercises, the command will have to make a conscious effort to use the Tyne engines whenever possible to achieve an approximation of the plan. The planning of passage speeds will require operational staffs to understand fully these problems.

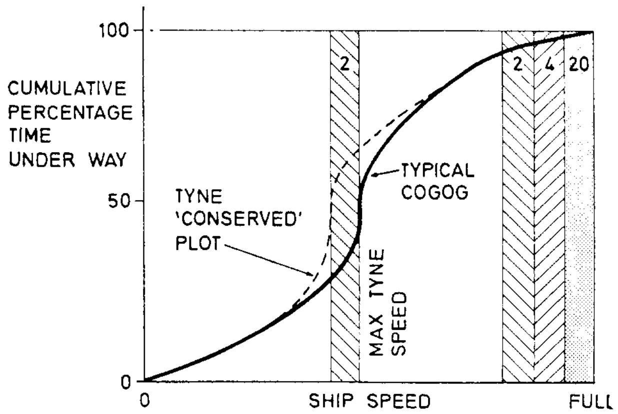


FIG. 3—TYNE AND OLYMPUS LIFE FACTOR POWER BANDS SUPERIMPOSED ON A TYPICAL CUMULATIVE PERCENTAGE TIME UNDERWAY/ SPEED PLOT FOR A COGOG SHIP

Engine Changes

Engine changes require a convenient port with a dock-side crane and air-freight of the spare GTCU if the ship is abroad. Ships may, therefore, expect to continue their programme with an unserviceable or time-expired engine until these facilities can be provided. Nevertheless, it should be noted that with an unserviceable Tyne there is no loss of full speed capability, only endurance, and vice-versa with an unserviceable Olympus.

Summary

To achieve the required balance of engine usage necessary to meet the projected engine change rates, it will be essential that MEOs thoroughly understand the problem so that they can advise their commanding officers accordingly. Such understanding by Fleet operational and technical staffs is equally important for the careful planning of ships' programmes.

Both the engine manufacturer and the design and refitting authorities will need to concentrate on improving with experience the engine and ship systems not only to reduce the incidence of random failures but also to lengthen the declared overhaul lives; without this the gas turbine concept will fall into disrepute.

Removal and Overhaul of Gas Turbine Change Units

Commander Shaw, Head of the Gas Turbine Section of the Ship Department, explained the removal procedures for the life-limited parts of the engines and the planning which is proceeding to enable this to be undertaken world wide together with the arrangments being made for the overhaul of engines.

Module Repair

Each gas turbine consists of a life-limited part (the gas turbine change unit—GTCU) and the rest. The 'rest' consists of the bedplate, the enclosure, much of the control system and, in the case of the Olympus only, the power turbine also. All these are designed to have the normal sort of long life associated with ship machinery. Their planned maintenance routines either are infrequent or can be done *in situ*; their breakdown should not occur at all! For these reasons, the upkeep of all parts of the gas turbine except for the GTCU is done either by ship's staff or dockyard or, more normally, sub-contracted by them to a manufacturer.

GTCU Removal

The GTCU is designed for upkeep by exchange and needs to be removed from the ship for every overhaul. Relatively minor work only can be done on the spot; changing the fuel pump or combustion cans of the Olympus are examples. The removal route for the GTCU is via its own intake; a few pieces of equipment need to be shifted first—the intake silencer splitters, the inlet cascade bend box, etc. This work can take place while the GTCU is being disconnected. The engine is guided up the intake trunk by rails; the rails inside the engine enclosure are permanently fitted there, and the long vertical ones are stowed elsewhere in the ship and are shipped when required. A sheltered berth is needed so that the GTCU can be lifted clear by crane. The first engine change is demonstrated by the shipbuilder as a contractual requirement.

Change Teams

These engine changes are simple in theory but they need art and skill to perform them fast. With practice however, such an operation can be done rapidly as an evolution. It is partly for this reason that engine changes will normally be carried out by the trained teams from FMGs either at naval bases or, when necessary, flown out to the ship. Each team consists of one junior officer or fleet chief, three artificers and nine others; a crane driver will also be needed. Ships' staff also are being trained to carry out engine changes so that they do not have to be dependent on outside help. It is not, however, the intention for them normally to carry out the change; it would take more out of them than boiler cleaning.

Transport

The engines are not light; the Olympus GTCU weighs nearly 3 tonnes (6500 lb) and the actual weighed weight of the Tyne is 1200 kg (2653 lb 8 oz). On land the engines are carried by road transport in their own storage crates; in UK this will normally be done by the Mobile Aircraft Repair Transport and Salvage Unit (MARTSU) which is the Fleet Air Arm organization manned by naval personnel that already carries out the same work for aircraft engines and indeed for whole aircraft. To and from abroad, engines will be shipped by air either by the R.A.F. on their main routes or, where necessary, by commercial airlines just as already happens with other urgent spare machinery. For flying, the engines are taken out of their crates and travel on their own stands clothed only in waterproof plastic bags as is normal aero engine practice. As the Olympus crate weighs 1½ tonnes, this is a worthwhile saving. The bigger engines can be transported in the Hercules or the Belfast; there is a greater choice of aircraft available for the Tyne. The R.A.F. have been looking into our crystal ball to plan their future deployment of aircraft.

Overhauls

This removal and transporting is necessary for the overhaul of the GTCU. In general terms, such overhaul comprises one or all of:

(*a*) Reconditioning, i.e. restoring the engine to the as new condition.

(*b*) Repair.

(*c*) Incorporation of modifications.

A special word is needed about modifications. They arise in greater number for aero and aero-derived gas turbines than they do for other machinery. This is because, whereas in most equipments modifications are introduced only to overcome weaknesses revealed in service, in marinized aero engines they also serve another purpose. As with all military and civil aircraft engines, in order to increase the availability and reduce through cost, their planned life is continually extended throughout their existence. This gradual realization of the full potential of the engines is achieved by incorporating modifications which are produced as the result of development work ashore.

The GTCU overhauls can be done either at the manufacturers (Rolls-Royce) or at the R.N.A.Y., Fleetlands, which is one of the Royal Navy's aircraft repair yards, civilian manned and largely under naval management, where the helicopter engines of all three services are overhauled. The facilities and skills available and the depths of repair undertaken are identical at Rolls-Royce and at Fleetlands. The reasons for setting up overhaul lines in these two places are many; in particular:

(*a*) Fire or disasters at one will not affect the other.

(*b*) Flexibility of loading between the two can counteract unevenness in their own tasks and also reduce the overall effect of local labour troubles.

Gas Turbine Allocation Authority

Commander Cobb, Head of the Depot Spare Machinery Section of the R.N. Supplies and Transport Services, spoke of the role of the Gas Turbine Allocation Authority in controlling the cycle to ensure that adequate spare engines are always available to the fleet.

Historical

Until about four years ago, the management of depot spare machinery was split between the Director-General Ships and the Director-General of Supplies and Transport (Naval). DG Ships identified and allocated the machinery as required and DGST(N) was responsible for its custody and accounting.

Early in 1970, the professional and technical staff concerned with depot spares were seconded from DG Ships to DGST(N) and a combined section was set up to deal with all aspects of management of this machinery. This section is known as DGST(N) 40B.

With the introduction of the Tyne and Olympus gas turbine engines as the main propulsion units for the fleet, it was recognized that an effective repair and support organization would be of paramount importance and a working party was set up to examine the whole subject of support of the gas turbine change units.

One of the recommendations of the working party was that a gas turbine allocation authority should be set up to administer these engines and to act as the co-ordinating link between all the authorities concerned, e.g. C-in-C Fleet, FONAC, DG Ships, HAD(N), CED, etc. Another recommendation was that the task should be given to DGST(N) 40B. Both these recommendations were accepted and DCI(S) 11/74 spells out the terms of reference for the Gas Turbine Allocation Authority (GTAA) and the policy and procedures for the administration of the Tyne and Olympus GTCUs.

Procedures

These procedures are necessarily more complex than for other depot spares because their administration requires up-to-date knowledge of the modification state and running hours of the units at sea as well as the location of all the units in store and under repair.

The GTAA is put into business by DG Ships who buys all the engines for first fitting and for the pool. This buy is based on the output of a computer programme which simulates the life cycle of the engines; the inputs to the programme include the ship building programme, the planned effective engine hours to the declared overhaul life, the estimated premature failure rates, the turn-round time for overhaul, etc. The output gives an estimate of the number of spare engines required to meet the estimated number of engine changes and the consequent overhaul work loads. These estimates will be updated as actual operating experience becomes available.

The life cycle of these engines can be dramatically affected by the mode of operation of the ships. To take the extreme example, indiscriminate use of the Olympus at life factor 20 will quickly choke up the overhaul lines, the throughput increasing until saturation is reached. Defective and life expired engines will then queue up waiting overhaul and there is a parallel reduction in the number of serviceable engines available for issue. Such a situation could only be stabilized by an immediate reduction in the fleet usage of the Olympus. Increasing the overhaul rate by, say, the introduction of overtime would not only take months to show any visible effect but would also depend on the immediate availability of sufficient stocks of the components from which the engine is made. Neither is the ordering of new engines an answer because it is component manufacture which absorbs most of the lead time; engine assembly is a relatively speedy process, measured in weeks rather than months. For example, it takes a skilled three-man team just five days to assemble an Olympus ready for test from the sub-assembly stage, that is with all the rotors bladed and balanced, etc.

Administration of the Pool

The pool of good engines will be held at the R.N. Aircraft Yard at Wroughton. This is a convenient place geographically to have them as it is half way between Rolls-Royce at Ansty and Fleetlands; it is near Lyneham and Brize Norton air fields and not very far along the M4 from Heathrow.

Returns of defective and life-expired engines are monitored by the GTAA who decides, in consultation with the overhaul authorities, where the engine will be overhauled, the depth of repair and the extent of modification to be carried out in the light of commitments and overhaul capacity. On completion of overhaul, the engines will be allocated by the GTAA to store or to service as appropriate.

Discussion on Gas Turbine Support

Asked whether a shipbuilder had yet demonstrated the removal of a gas turbine, the panel replied that for H.M.S. *Bristol* this had not yet been done but it was planned for June 1974; for H.M.S. *Sheffield,* it will be demonstrated before CSTs.

To a question asking what the advantages of gas turbine propulsion were, the reply given was that there were several, namely: the development costs had already been paid by the aircraft industry; a higher power/weight ratio; upkeep by exchange can be used more extensively; a higher availability was forecast (15 per cent. above *Leanders*); and that simple controls can be fitted. Admiral Raper stressed that the quality of engineering skills was enhanced and that industry is not prepared to make steam plant of the required reliability.

It was also pointed out that although first costs of gas turbines were higher, life costs were lower. A saving in manpower was possible in gas turbine-fitted ships—52 ME ratings in a Y160 *Leander* against 34 in a Type 22 frigate.

Captain Coleman, CSO(M) to FOSM, stated that FOSM controlled the operating pattern of nuclear submarines by controlling their effective full-power hour usage and he inquired whether similar controls could be used for gas turbine-fitted ships. It was stated that a form of control of the effective hours usage as in nuclear plants was going to be used for gas turbines.

A question was raised as to whether gas turbine life was sensitive to fuel quality. In reply it was stated that, although fuel costs in gas turbines were less than in equivalent steam plants, fuel quality was one of the variables that could affect engine life. The effects of salt contaminants and water in fuel have been simulated in shore trials, but the applicability of these trials to sea conditions is not yet fully known.

To an inquiry, it was stated that there were 28 Olympus in service and 59 in store.

SUPPORT OF WEAPONS SYSTEMS

Weapons Acceptance

Captain Leathes, Captain Surface Weapons Acceptance, stated that the aim of DGW(N) Acceptance Procedures is to provide an independent assurance that the system or equipment meets the standards prescribed in the Naval Staff Requirement as amplified by the Agreed Characteristics.

Introduction

This paper deals with the organization at ASWE for surface weapons acceptance; there is also a similar organization at AUWE for underwater weapons acceptance. Both these establishments are now fully civilianized, each with a civilian Director responsible to the Controller R and D Establishments and Research (CER). Within ASWE and AUWE are the three Project Directorates responsible to DGW(N). There are two directors at ASWE—one civilian, Director Weapons Surface Projects (DWSP) and the other naval, Director Surface Electronic Projects (DSEP); the remaining director, a civilian, is the Director Underwater Weapons Projects (DUWP) at AUWE.

History

The present organization was established in the summer of 1972. Hitherto the Projects Directors were responsible for accepting their own wares. The management of the Establishments was therefore responsible not only for producing the weapon but also for accepting or even condemning it, i.e. judge, jury and executioner in one! The Acceptance Authority is now entirely independent of the Project Directorates and the Directors of the Establishments and is responsible direct to DGW(N) through the Director Weapons Co-ordination and Acceptance (DCWA); nevertheless, both the Project Directorates and the Captain Surface Weapons Acceptance (CSWA) work for DGW(N).

Personnel of CSWA

No additional personnel were required on the formation of the Acceptance Authority because a small slice was hived off what had been Director Weapons Equipment Surface (DWES) organization on the introduction of MOD(PE). Apart from CSWA, there is one experienced WE commander and two seaman lieutenants, both sub-specialists, who are responsible for compiling the acceptance documentation and preparing the acceptance procedure for each project. CSWA also has the part-time use of three seaman sub-specialist commanders whose responsibility is to keep him in touch with their projects and to assist in the compilation of the acceptance documentation.

The Acceptance Procedure

The acceptance is a process by which DGW(N) and, in turn, the Admiralty Board and the Fleet can have full confidence that the equipments or systems being procured for the Royal Navy, even if of foreign origin, are suitable for fitting in the Fleet. It is a once only process for each project and culminates in Fleet Weapon Acceptance (FWA) with consequential cancellation of the Naval Staff Requirement and the transfer of the project to post-design.

The aim of this procedure is to provide an independent assurance that the equipment or system meets the standards presented in the Naval Staff Requirement as amplified by the Agreed Characteristics. Acceptance must ensure not only that the performance (including software, if applicable) meets these standards but also that adequate provision is made in all associated fields. These include:

Operability	Upkeep and Support
Availability	Documentation
Compatibility	Training
Installation	Security
Safety	In-service Management
Reliability	Post Design.
Maintainability	

It is a continuous audit process whereby the Project Manager produces the 'books' for examination throughout the progress of his project so that, on completion, sufficient evidence has been collected by CSWA to enable him to recommend Fleet Weapons Acceptance of the project.

However, it must be emphasized that this procedure in no way usurps the authority or responsibility of the Project Manager to meet the Naval Staff Requirement within the constraints of time, cost and practical engineering. In practice, meeting the Naval Staff Requirement completely may be neither practicable nor cost effective, and therefore CSWA's recommendation for Fleet Weapon Acceptance may contain some acceptable qualifications. The important point is that these qualifications will now be defined to the Admiralty Board and the Fleet with any proposed corrective action that is considered desirable.

The time cycle to Fleet Weapon Acceptance of an average project can be anything from six to ten years. As the present organization has been functioning for only eighteen months, no project has yet been seen through from conception to birth (although there has been a sudden death or two!). The formal acceptance procedure starts when the Staff Requirement is approved or re-endorsed and ends with the final acceptance (Fleet Weapons Acceptance) when the project goes to post-design. The crucial point in this cycle is at the end of the development stage when the project goes into production and the contract is signed. At this stage it is necessary to be confident that the equipment will be acceptable and at this point if all is well a Provisional System Acceptance is given. For some projects, certainly for large weapon systems, it may be necessary to go into production before trials on the development model have been completed—Sea Dart is a case in point. It is thus even more important that the project is adequately monitored, particularly in the early stages.

Instruments of Acceptance

Weapon Acceptance Committee (WAC). This is the main committee chaired by CSWA and comprising representatives of the Project Authority, Director of Naval Operational Requirements, Captain Weapons Trials, Chief of Fleet Support and other interested authorities. This committee, which meets at least annually on each project, is further divided into three working parties which deal with the specific requirements and problems of performance, upkeep and support, and trials.

Questionnaire. This is the basic document of acceptance. It is derived from the Naval Staff Requirement, the Agreed Characteristics, and certain general Naval Weapon Specifications which are translated into a questionnaire by the Acceptance Authority working in close liaison with the Project Authority. From this questionnaire the schedules for the various trials are formulated by the Project Manager for the Captain Weapons Trials, who is responsible neither to CSWA nor to the Project Manager; thus the independence of the final acceptance is further strengthened.

Summary

The Acceptance Procedure is a progressive audit of the project which ensures that the Naval Staff Requirement is met in full, or with acceptable qualifications, and that the equipment or system will be satisfactory to the Fleet. To achieve Fleet Weapon Acceptance of a project, mutual trust and co-operation between the Acceptance and the Project Authorities is essential: this, it is hoped, exists. Although CSWA may be independent of the Project Authority, he belongs to the same firm and the mutual aim is the same, namely: the Support of the Fleet.

Weapons Trials

Captain George, Captain Weapons Trials, opened with a brief description of the organization of the Trials Authority. Captain Weapons Trials (CWT) works for the Director-General Weapons (Naval) through the Director of Weapons Co-ordination and Trials (DWCA). The post may be held by a WE captain or seaman captain of any sub-specialization. CWT's organization is quite large comprising 56 officers, 67 senior ratings, 42 junior ratings, 17 WRNS, and 93 non-industrial and 40 industrial civilians. 33 of the serving officers and 63 of the ratings are of the WE specialization.

Captain Weapons Trials went on to say that, as Captain Surface Weapons Acceptance (CSWA) had already alluded to the part played by CWT in the Fleet weapons acceptance process for new design equipment when first fitted, his own paper would concentrate on the procedure which CWT follows in a new ship during the period from setting-to-work until the ship becomes operational for the first time.

Before the setting-to-work of weapon equipment can begin, it is subjected to what CWT considers to be the most important of all his inspections, namely: the Installation Inspection.

Installation Inspection

The Installation Inspection is carried out to ensure that:

(*a*) Equipment has been fitted and secured correctly in accordance with the approved drawings, installation specifications and other relevant fitting-out information.

(*b*) All other installation work, tests and checks, listed in the approved installation inspection test forms as a pre-requisite for setting to work and testing and tuning, have been satisfactorily completed. Where QA (Ships) is a condition of contract, the shipbuilder will provide the CWT inspection team with an overall certificate in accordance with the Naval Weapon Specification.

(*c*) The equipment is in all respects ready for the commencement of setting to work.

Experience has shown that, if a good clean Installation Inspection is achieved and the setters-to-work are allowed their full period in which to work free from interruptions, the ship is likely to arrive at Operational Date without major problems in the weapons area.

Acceptance Trials

When the Weapon System Tuning Group (WSTG) has completed the setting-to-work process, usually in a south coast port, CWT is called in once again to carry out the Harbour Acceptance Trial (HAT). The HAT is carried out on completion of setting to work and testing and tuning in order to confirm that the equipment or system is ready for service, free from defects (as far as is practicable) and working in accordance with the approved schedules or relevant reference books. By the time that HAT is reached, certain ship's services such as stabilized power supplies, chilled water, H.P. air, ventilation, fire-fighting systems are required. For this reason, the WEO and the MEO must be working closely together at this stage to produce a 'whole ship' approach.

For equipment which has been in service for some time, the HAT is a routine operation and CWT is merely carrying out a Ship Weapon Acceptance. If the equipment is a new one and is a candidate for Fleet Weapons Acceptance, the Harbour Acceptance trial is designated HAT(F). In this case, CWT is working on behalf of the project authority with the object of furnishing the Project Manager with the data he is required to produce to CSWA or Captain Underwater Weapons Acceptance (CUWA) when seeking Fleet Weapons Acceptance. HATs (F) therefore involve CWT's organization and the project authority working closely together before, during and after the trial.

The Sea Acceptance Trial (SAT) which follows the successful completion of the HAT consists of those parts of the acceptance trial which cannot be carried out in harbour. The interval between HATs and SATs should be long enough to allow defects found during the HAT to be rectified but, in order not to invalidate the HAT results, should not exceed the period laid down in the trials schedules. If a long interval cannot be avoided, a partial repeat HAT must be carried out. The Sea Acceptance Trial also confirms that operation of the equipment does not suffer from interference or hazards caused by vibration, shock or electro-magnetic transmissions from other equipments in the ship. If the equipment is a candidate for Fleet Weapons Acceptance, the SAT is designated a SAT(F) and similar considerations to those concerning the HAT(F) apply.

The satisfactory conclusion of the SAT series across the weapons field (communications, radar, TAS, gunnery and guided weapons and computers) completes CWT's current involvement in the ship which, from the weapons point of view, is then clear to proceed to her Operational Date Inspection and thence work up.

For weapon equipment seeking Fleet Weapons Acceptance, the story does not end there. For a new weapon system or equipment a comprehensive set of ship firing trials is carried out during which the weapon system or equipment is operated in all its modes. The aim is to show that the performance of the complete system or equipment meets the staff requirement. These trials are conducted by the Commanding Officer of the ship to schedules written by the Project Authority and endorsed by the Acceptance Authority. When Fleet Weapons Acceptance of a system or equipment does not involve firings it can be assumed that successful completion of HAT(F) and SAT(F) indicates that the equipment has been operated in all its modes and that the performance is in accordance with the staff requirement or that qualifications thereto are acceptable.

The process of accepting ships and weapon systems into service is a logical one, starting at the very beginning of the ship's life and going through to her operational date. CWT's involvement, however, does not stop at the first operational date inspection. Throughout the ship's life, on completion of major and normal refits, CWT carries out trials on weapon equipments and systems after major refits as a mandatory task, and after normal refits on behalf of the Commander-in-Chief, Fleet, when the necessary effort is available.

Independence of CWT

Although CWT's organization forms part of the Weapons Department and is accountable to DGW(N) through the Director of Weapons Co-ordination and Acceptance (Naval) (DWCA(N)), it enjoys a unique position of independence. While naturally conforming in the matter of personnel, administration, etc., no pressure is brought to bear to change any judgement or report the organization makes. This is not to say that the projects authority, Captain Weapons Acceptance, or DGW's headquarters staff have necessarily agreed with all CWT has said—far from it—but no one has ever questioned his right to say it, and due consideration has been given to his remarks. That gives the real indication that the Weapons Department is paying much more than lip service to the ideals of an autonomous and independent acceptance authority.

Length of Trials Period

A contentious point with weapons trials is their length, generally thought to be far too great. At present a whole series of new ships and weapon systems is being introduced into service in the Royal Navy. In some cases this involves a new weapon in a new ship (Sea Dart in the Type 42 destroyer) and in others a new system in an existing ship (IKARA and ADAWS 5 in the Batch One *Leander* Class). The figures of eighteen months for H.M.S. *Sheffield* and ten months for H.M.S. *Leander* for weapons trials are revealing. Even more surprising is the figure for H.M.S. *Bristol,* for she will have been engaged on weapons trials and evaluation for three years by the time she starts her first refit and proceeds from there to her first Operational Date.

The trial times for first-of-class ships allow for very extensive proving of the system to enable the project authority to amass sufficient evidence to obtain Fleet Weapon Acceptance, and include long periods necessary for the proving of software in centralized computer-based ships. The project authority also has to prove the documentation during this period. The time for trials in follow-on ships, which are conducted by CWT's organization without the involvement of the project authority, is about half that for the first-of-class ships.

There is scope for reduction in the time taken for post-refit trials carried out by ships after normal refits. For example, the fourteen weeks of trials after twenty-six weeks of refit scheduled for DLGs 05–08 is disproportionate. A successful experiment has recently been carried out in H.M.S. *Norfolk* in which the trials period was reduced to ten and a half weeks, and it is felt that there is room for still further reductions for this and for other classes of ships thus improving their operational availability. In order to achieve this, the Weapons Department in conjunction with the Commander-in-Chief, Fleet, is looking at a new philosophy of weapons trials. The aim of these shorter trials is to give the Commanding Officer a confidence level demonstration on weapons equipments which have been successfully kept alive during a normal refit. The key to this lies in the words 'successfully kept alive', the achievement of which, Captain George said, is fortunately not CWT's concern but is, he suspected, very much the concern of a number of the readers of this article.

Present and Future Considerations in Weapons Systems Upkeep

Captain Wale, Deputy Director of Weapons Co-ordination and Acceptance (Naval), said that Upkeep had been chosen as the subject of this paper because of the paramount importance it has now assumed in procuring and supporting ever more complex and costly weapons systems against a steadily reducing budget. It is only in recent years that there has come about a full realization of the relatively large proportion of total ownership cost that is invested in support and the need and potential for making significant savings in this area. Support costs are distributed over the whole life of an equipment and the expenditure on spares, as against the cost of capital equipment, has increased sharply over the last ten years. Clearly, taken over the life of an equipment, the money spent on upkeep is likely to far exceed the original cost of the equipment. A current estimate is that the upkeep cost over twenty years is of the order of four or five times the first cost.

This paper outlines what DWG(N) is doing, or planning to do, to ensure that these costs shall be kept to a minimum commensurate with an acceptable performance and operational availability. Achievement of this objective begins with the formulation of the equipment Naval Staff Target.

Naval Staff Requirements

The concept of a new weapon equipment begins with the Staff Target, which expresses broadly the functions and desired performance of the equipment before undertaking a study of its feasibility and the writing of the Equipment Staff Requirement. The object of this study is to determine whether the target can be achieved and to what extent it should be possible to meet the operational needs of the Naval Staff. The dialogue between Project Management, Naval Staff, and Support Departments begins during this phase with the identification of possible trade-offs between Reliability, Maintainability, Availability and Operational Performance so as to arrive at the best balance. For instance, a given Availability may be achieved by high Reliability or by high Maintainability, and the most cost-effective balance between the two is sought. The level of Operational Performance demanded affects the sophistication of the design, which in turn affects the Reliability and Maintainability that can be achieved.

Strangely and perhaps illogically, there has hitherto been no requirement to include an assessment of upkeep costs amongst the factors considered. DGW(N) is now taking action to remove this anomaly by proposing that through-life upkeep cost considerations should be included in the 'trade-off' dialogue between the Project Management and the Naval Staff, and of course Departments under the Chief of Fleet Support. In some cases the Project Manager may be able to show the Naval Staff that a very slight lowering of the Availability requirement would permit substantial reductions in spares support costs or allow the use of a preferred, tried and cost-effective design philosophy. For instance, taking a recent VHF/UHF equipment, the NSR originally specified a 97·5 per cent. confidence of no failures in a 100-day mission and to meet this requirement the onboard spares holding was assessed at 42 per cent. of the capital cost. By reducing the requirement to 90 per cent. confidence on a 45 day mission, or 60 per cent. on a 100-day mission, the spares holding falls to 20 per cent. of the capital cost. The original requirement was in fact modified. Again, whereas the Equipment Staff Requirement caters for the most stringent case (such as when only one set is fitted in a ship), reduced Availability and mission times for other fits (such as multi-fits which allow redundancy) could considerably reduce the spares support costs.

The factors affecting upkeep costs to be considered when taking 'trade-off' decisions include:

Equipment complexity
Repair Policy
Spares Support
Maintenance and repair manpower training
Special test and repair facilities
Documentation (presentation and contents)
Installation, setting-to-work and trials
Form of construction.

It is proposed, then, that costs of upkeep will henceforth come under close scrutiny from the conceptual stage of a new equipment, with the Naval Staff being invited to modify their originally-stated requirements throughout development whenever a significant saving can be identified. The upkeep cost estimates will, of course, be progressively refined and updated during the whole process of development and it is the aim that the upkeep costs of future weapon equipments should be predicted with reasonable confidence well before the equipment enters service. All this is, of course, easier said than done. At present a Project Leader has little more than engineering judgement to guide him in determining the various options and trade-offs which affect costs. Action is now proposed to provide firm guidelines, as is explained later. Before leaving the subject of Staff Requirements it is perhaps worth noting that the equipment Staff Requirement may precede by five years or more the Staff Requirement for the ship in which it may be fitted.

Upkeep Plan

One of the Project Leader's next tasks is to assemble the Upkeep Plan. This plan is built up from a number of major parts, most of which contain some components of the factors of Availability, Reliability and Maintainability (these oft-repeated factors are henceforth referred to by their conventional initials A, R and M).

The first part of the Upkeep Plan comprises the Upkeep Statement in the Staff Requirement. This statement contains the factors A, R and M, through-life costs, manpower requirements, and setting-to-work times. To support the upkeep requirements in that list, it is necessary to have Reliability and Maintainability Programme Plans. In these, the designer is required to show how the specified R and M will be achieved; this he does by using Reliability predictions, failure rate predictions and the results of trade-off studies. Also in the Upkeep Plan is a Repair Capability Forecast. This makes a statement on the facilities which need to be, and are forecast to be, available in the Royal Dockyards, in Industry, or in Fleet Maintenance Bases for testing, repair or overhaul of the equipment.

Finally in the Upkeep Plan, and of fundamental importance, comes the Upkeep Policy Statement. To draw this up, requirements for upkeep at all levels must be considered in detail. The Project Leader is required to make efforts to minimize upkeep requirements both in operational and non-operational periods.

For *operational periods,* consideration is balanced between the repair policy, maximum availability, the volume of onboard spares, and the level of ships' staff's skills. For *non-operational periods,* there must be an attempt to minimize the disruptive effects of dockyard and ship's staff work. Where 'keep alive' is a necessity to avoid these disruptive effects and to prevent protracted setting-to-work periods, the arrangements for 'keep alive' must be allowed for in the design stage and stated in the Upkeep Plan.

In the factors affecting the Upkeep Policy Statement mention has been made of the Repair Policy. In the same way that 'horse-trading' goes on between Project Leaders and the Naval Staff and CFS Departments over the factors A, R and M, so also must the Project Leader examine the conflicting requirements of the Repair Policy with the Naval Staff and CFS Staff and negotiate a cost-effective compromise solution.

Basically, the Repair Policy is a mix of two options—Repair onboard or Upkeep by Exchange. Some of the disadvantages of each of these options which need to be balanced against each other are:

(*a*) For repair at component level:

- (*i*) More expensive documentation to cover the lower level of diagnosis and repair;
- (*ii*) More highly trained ship's staff to undertake these tasks;
- (*iii*) More complex EMR/LMA facilities;
- (*iv*) Longer down times.

(*b*) For repair by module:

(*i*) Higher cost of spares;
(*ii*) Limited onboard repair capability in the event of unexpected damage or failure;
(*iii*) A requirement for more comprehensive logistic support and shore repair facilities.

As already mentioned in relation to the establishment of trade-offs, in balancing all these factors against one another the project leader is working very much on engineering judgement. What we have not yet been able to produce is a method whereby an optimum upkeep policy can be determined from a full knowledge of the effects of such variables as:

Equipment population
Ship role and deployment
Logistic support
Repair policy
Manpower and training
Shipfitting and post-design policy
Equipment complexity
Equipment construction
New engineering techniques.

Action is in hand to remedy this.

One more aspect of the upkeep policy that requires examination is the possibility of dividing weapons equipment into three main categories as follows:

(*a*) Ship fitted—normally in use.
(e.g. gyro-compass, navigational radar, plots, communications)

(*b*) Ship fitted—normally at stand-by.
(e.g. weapon systems embracing fire control, missiles, launchers, guns, torpedoes, sonars, radars, weapon handling equipment)

(*c*) Shore fitted.
(e.g. trainers, ship equipment fitted ashore).

Each category could merit a different support policy since the Availability and Usage requirements are different. For instance, the Gyro-compass and Navigational Radar are normally in use at sea and cannot readily be taken out of service for maintenance. On the other hand, systems which are normally at stand-by, even though they must often be at a very high state of readiness, need not normally suffer such stringent constraints on maintenance, and it is reasonable to expect that the same support policy is not appropriate for both. It is also fair to assume that this would result in significant savings in support costs.

It may be that the whole upkeep policy equation is a subject for computer programme treatment. However, in the first instance the complexity and size of the task to produce numerate guidance for designers can only be tackled realistically by allocating effort and money to a deep study. DGW(N) is therefore proposing to set up a special project to quantify the effect of all the variables which affect upkeep policy. This project will be led by an officer experienced in fleet and design project problems. The aim will be to produce a document giving firm guidelines which quantify the effects of the variables, and so provide basic information upon which a Project Manager could base his decisions for a particular project.

Summing up, the Upkeep Plan is an amalgam of upkeep requirements and forecast repair capabilities, intermingled with R and M predictions of sometimes doubtful origin and an Upkeep Policy refined from a wide solution of variables. One thing stands out: development of the Upkeep Plan must commence at the staff requirement stage if a sensible balance is to be struck between operational requirements and upkeep costs.

Post-Design and DGW(N) In-service Management

It would be advantageous to be able to iron all the 'bugs' out of an equipment before putting the production model to sea. However, constraints of time, money and effort prevent this. Although DWG(N) goes as far as he reasonably can, he must then depend upon those shortcomings which affect R and M being revealed by practical usage at sea. This makes Post-Design a most vital activity and it is particularly important to ensure that part of the original design team joins the Post-Design organization.

The link between the Post-Design organization and the Fleet is provided by the Management-in-Service division, which handles all technical problems beyond the resources of the Fleet and dockyards, analyses all inspection and trial reports, defect reports and similar feedback provided by the SMA, and institutes remedial action with the Post-Design authority.

Upkeep Data

DGW(N) is in the process of reconsidering precisely what data is required from SUIS and MIDAS to support the upkeep policies just outlined. The re-organization of the PE departments following the Rayner Report has necessitated a review of the whole of the Weapon Department's information requirements. In considering what these requirements are, staff cuts against an increasing work load have made it very necessary to differentiate clearly between information which is really valuable to the Department and that which is merely interesting. It must be emphasized that the Weapon Department is facing the biggest weapon development programme that has ever been undertaken.

'Keep Alive' and Temporary Supplies and Services

Finally, in briefly considering the maintenance of weapons equipments during refits and the setting-to-work of these equipments during building and after long refit, Captain Wale said that it is increasingly important that a refit or building programme is drawn up in very close conjunction with the weapons setting-to-work programme. This calls for a depth of detailed planning and a consideration of interdependencies between systems which is a radical departure from what has been considered 'adequate' in the past. It requires very close co-operation between ship's staff and the dockyard or shipbuilder. One of the fundamental features of such a programme is the provision or retention of 'keep-alive' services in normal refits and the provision of temporary services in new construction programmes or long refits. By taking these steps, weapons equipments can be brought into operation during building, or operated either continuously or periodically during refit, when permanent services or supply systems are either incomplete or under repair. During building this enables setting to work to begin many months earlier than would otherwise be possible (for instance, the complete setting to work of a GMD missile handling system can take up to twelve months). By providing temporary supplies valuable programme time can be saved. The same applies during a refit, where 'keep alive' also avoids a high incidence of defects after a long shut down. Although the times saved in this instance are clearly of a different order, they are nevertheless very significant. 'Keep alive' and temporary services have also become an integral part and a prerequisite of the actions taken to reduce the length of post-refit sea trials by the simple expedient of redesignating certain Sea Acceptance Trials as Harbour Acceptance Trials and then completing them, together with the HAT programme, inside the non-operational period of a refit. Recent experience with H.M.S. *Norfolk* has pointed the way to a means of reducing the SAT programme time by several weeks.

Summary

This paper has aimed to give a brief description of some of the considerations which go towards determining the Upkeep Policy for a weapon equipment and in particular what is being done to ensure that upkeep costs are kept to a minimum commensurate with an acceptable performance and operational availability. To summarize the main points:

(*a*) It is the aim to determine an order of Through-life Upkeep Cost options at the conceptual stage of an equipment, for inclusion in the trade-off talks between the Project Management and the Naval Staff. This is a basic essential in minimizing support costs.

(*b*) The determination of Upkeep Policy is related to a number of variables. At present the effect of these is largely a matter of engineering judgement. Action is in hand to undertake a deep study with a view to quantifying the effect of these variables, and so to provide numerate guidance to help a project manager to choose the optimum Upkeep Policy for a given equipment in a given situation.

(*c*) Upkeep data requirements must be limited to information which is really important and not just interesting.

(*d*) Provision must be made for the optimum use of temporary or 'keep-alive' supplies and services in order that the lengthy weapons setting-to-work and trials programme may be minimized.

Discussion on Support of Weapons Systems

The first questioner asked whether weapon packages were being designed in such a way that Upkeep by Exchange could be applied in a similar manner as that applied to gas turbines. The panel replied that certain weapon systems, like the type 909, had extensive testing and tuning at the manufacturers before being installed but major systems had not yet been packaged. This was being investigated at the moment by WE officers appointed to the project authorities.

An officer standing by a frigate during a long refit asked whether it was not possible for the ship's staff standing by to be usefully employed helping in the setting to work of weapon systems before CWT's inspection. The reply was that CWT was required to accept weapon systems and that it was from the dockyard that they were accepted. Admiral Griffin confirmed that the dockyard were reluctant for the ship's staff to work on any system before CWT's inspection.

Discussion was then centred round whether the Dockside Test Organization (DTO) could play a larger part in weapons acceptance. CWT was of the opinion that the DTO as at present constituted was not competent to take over the role of weapons acceptance authorities but, as confidence in DTO is built up, it may be possible for the DTO to take a larger share in the acceptance process.

The panel were then asked if any thought had gone into the inspection of the ship's systems that support weapons on the same basis as the weapons themselves. The reply was that DGW(N) does look at support systems but has no direct control over them.

SUPPORT OF AVIATION MATERIAL IN SHIPS

Captain Clarke, Assistant Director Material in the Aircraft Department (Naval), opened by saying that a ship's Aviation Material is defined as her embarked aircraft complete with all their weapon system attachments together with the ship's facilities, fittings and stores provided specifically for aircraft operation and maintenance. Weapons stores, such as missiles, torpedoes or pyrotechnics, are not included since, although they justify the presence of the aircraft as a delivery vehicle, they are not provided primarily for an aviation purpose.

The changing structure of the fleet has resulted in a decrease in the number of ships capable of carrying a squadron or squadrons of aircraft and hence warranting an air engineer officer. At the same time, the number of ships which carry only one or two aircraft and no air engineer officer has increased steadily. In consequence, by the later stages of this decade the majority of front line embarked aircraft will be deployed in small ships.

This paper outlines some recent changes in departmental responsibility for general support matters and then concentrates on a particular area of interest which in some way concerns all engineering specializations, namely, the support of air material in naval-manned small ships and, in particular, those which will carry Lynx helicopters.

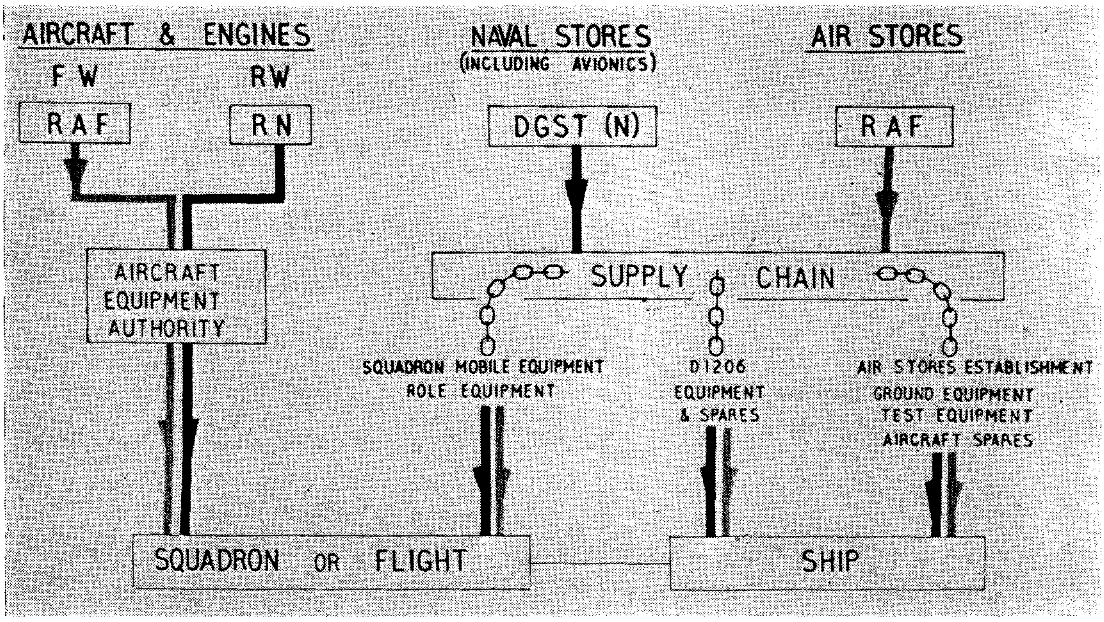


FIG. 4—RESPONSIBILITY FOR AVIATION MATERIAL SUPPORT

Responsibility for General Support Matters

Recent changes in responsibility for support matters resulted from the Templar Committee investigations into the rationalization of material management within the Ministry of Defence (FIG. 4). One of the results is that the Royal Navy is now responsible for the storage and repair of helicopters and their engines for all three services, while the Royal Air Force has similar responsibilities for fixed-wing aircraft and engines. In addition, the R.A.F. is responsible for the provision of all air stores. In order to keep onboard administrative and accounting procedures unchanged, the Royal Navy Air Stores Demand Centre at Llangennech provides an interpretation service for air store demands into R.A.F. language, and monitors the supply of air stores to the Fleet. FONAC continues to control the allocation of all naval aircraft and engines.

The small ships' flight will soon be the typical method for deploying naval aircraft to sea. The DLGs will continue to operate the Wessex 3, while the Wasp is at present the other helicopter in general use in frigates and survey ships. The paper now outlines the current support system for Wasp ships and then discusses the applicability of this system when the Wasp is replaced by Lynx.

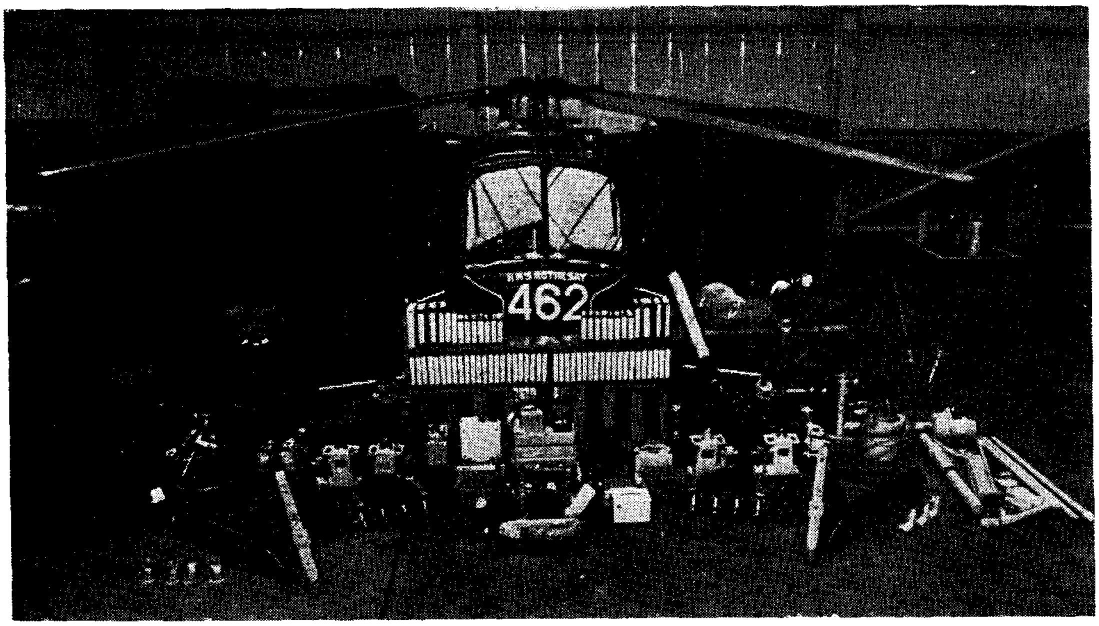


FIG. 5—WASP HELICOPTER AND OUTFIT OF AIRCRAFT HANDLING AND MAINTENANCE EQUIPMENT

FIG. 6—LYNX HELICOPTER

Support System for Wasp Helicopters

The maintenance crew of a Wasp flight consists of six air engineering ratings, who normally operate remote from the immediate supervision of an air engineer officer. Therefore, the senior air maintenance rating is responsible to the Flight Commander for the air engineering standards in the flight. FOCAS provides such technical supervision as is possible either directly or through the parent squadron, which he tasks.

The aircraft maintenance system can be compared in part to Upkeep by Exchange. When defects are diagnosed they are, in most instances, rectified by fitting a serviceable spare, the more complex components being identified as Line Replacement Units (LRUs). LRUs in a frigate include a spare engine, a spare set of main and tail rotor blades, spare hydraulic components and a spare for each significant electronic component. As the provision of the relevant test and repair equipment to Wasp ships is impracticable, defective units are recycled by return to the United Kingdom for processing through a repair line. Thus, an adequate allowance of spares and an effective pipeline for their supply and recovery is necessary.

The flight maintenance crew embarks and disembarks with the helicopter, taking with it an outfit of aircraft handling and maintenance equipment called Squadron Mobile Equipment (FIG. 5). There is also a great deal of ship fittings and equipment on which the flight depends, but for which the flight ratings can be made only partially responsible and then only when they are embarked. These include the flight deck, the hangar, winch, flight-deck lighting, communication equipment, power supplies, fuelling points, air workshops, ground handling equipment and a wide range of aviation stores.

In such ships, the Weapons Electrical Officer provides the overall coordination for all ship facilities obtaining assistance from the flight maintenance crew when it is embarked. When the flight is disembarked, the WEO assumes responsibility for the preservation of all aviation material that is not the specific responsibility of another department.

Support for Lynx Helipcopters

The Lynx (FIG. 6) is being developed specifically to meet a Naval Staff Requirement as an essential component of the main weapon system in all new destroyers and frigates, as an extension to the ship as a weapon platform. This is shown by the increased emphasis placed on its primary roles compared with the Wasp (FIG. 7). This, however, brings increased complexity which inevitably affects the maintenance required.

	WASP	LYNX
PRIMARY	ANTI-SUBMARINE WARFARE	ANTI-SUBMARINE WARFARE RADAR SEARCH SURFACE STRIKE
SECONDARY	SURFACE STRIKE RESCUE VERTICAL REPLENISHMENT TROOP CARRYING (4)	RESCUE VERTICAL REPLENISHMENT TROOP CARRYING (8)

FIG. 7—COMPARISON OF HELICOPTER ROLES

Since the Lynx will also be dispersed singly, the maintenance that can be carried out on it will be subject to limitations similar to those applying to the Wasp. The maintenance crew is the same as that for the Wasp with the addition of a senior air radio rating. The maintenance policy for the Lynx will, therefore, be based upon that for the Wasp; whether this will include spare LRUs to each ship depends on the current review of Fleet Support policies.

The Naval Staff Requirement specifies high reliability for each system in the Lynx but, because of the multiplicity of these systems, the probability of the helicopter remaining serviceable in all its roles after an assumed month's flying time of 30 hours is less than 50 per cent. Statistically, if provision could be made for one spare LRU of each type, the probability of the aircraft remaining serviceable at the end of the month rises to 80 per cent.

Whether or not ships can be provided with a full allowance of LRUs, the maintenance policy will still depend on replacement of defective units and their return to U.K. for subsequent repair. A significant proportion of defective units will be capable of being made serviceable by routine maintenance in a service-manned workshop, and the workshops at the R.N.A.S., Portland, may be given the capacity to do this. Those equipments requiring servicing beyond second line level will be routed to the conventional repair pipeline.

In some respects, the Lynx will make fewer demands on the ground crew than the Wasp. The latter requires the active attention of the ground crew when it is taking off, whereas the Lynx will be provided with a harpoon device which, by engaging in a grid in the ship's deck, will enable the aircraft to land, rotate and take off without any handling by the ground crew. However, because of its weight and its dynamic form which provides few handholds, the flight crew normally will be unable to push the aircraft by hand and some form of powered mechanical aid must be available whenever it is to be launched. The hydraulic winch system now fitted for use with Wasp is being re-engineered to improve its reliability and performance. A small electrically-powered aircraft handler will also be provided.

Systems Approach

Until recently the availability of some ship-fitted aviation equipment, in particular the aircraft winch, was inadequate. The main reasons for this were incomplete maintenance documentation and poor definitions of maintenance responsibilities; with improvements in these areas, the availability has risen. These shortcomings would not, however, have occurred if the operating and maintenance facilities had originally been identified as components of a ship weapon system. It is encouraging to learn that a systems approach towards aviation arrangements is being adopted in the Type 21 frigates and the Type 42 destroyers.

Refit Periods

During a typical refit period, since the flight is disembarked, the ship's officers must monitor the refit activities that affect the ship's aviation facilities. In current ships, this burden falls to the WEO. Specialist guidance can, however, be obtained from FOCAS, who undertakes the pre-refit inspection on behalf of the CSO(T) Fleet and the HATs and SATs on behalf of the Aircraft Department. Some assistance can also be obtained from the senior air technical ratings who although tasked by FOCAS are usually located within Fleet Maintenance Groups. One of these normally carries out an informal check of the aviation material before the HAT(Air). Ships' and dockyard officers who require specialist advice can consult FOCAS's staff or the Ships and Bases Section of the Aircraft Department or NATEC.

These procedures have been described in outline in BR 766A, recently promulgated to the Fleet. The Aircraft Department are currently considering ways to use this BR to promulgate guidance on the preparations required for HATs and SATs (Air).

Summary

The Fleet depends upon helicopters as components of the main weapons systems in the majority of its ships and will increasingly do so in the future. By the end of the decade, a large and increasing proportion of these helicopters will be Lynx which will have to be maintained and supported on similar lines to the Wasp. However, the component parts of the Lynx are much more expensive and resources will have to be managed carefully if the aircraft is to be maintained at an acceptable availability within economic limits. But, even if the helicopter is adequately maintained, it will depend for its operation upon the ready availability of the ships' aviation facilities; this thus justifies the adoption of a systems approach for their maintenance and support.

Discussion on Support of Air Material in Ships

More information was requested on whether there were any courses for ships' WE officers on their responsibilities in the field of support of air material. At the moment there is only a half-day course at H.M.S. *Collingwood,* but it is hoped to improve this.

Some concern was expressed at the increasing breadth of responsibilities of the WEO of a frigate. It was felt that the added burden of being in charge of the aviation support systems loaded him unfairly. It was pointed out that no further personnel could be obtained to relieve this pressure due to manpower shortages. It was stated further that, during periods that the ship's flight was disembarked, an organization within the ship had to exist to be responsible for these systems, and it was felt that the WE department was best suited to have the overall co-ordinating function. It was felt that the introduction of SUMS, with its systems approach to responsibility, would assist in raising the standard of upkeep of these support systems.

A question which obviously found a large measure of support from the audience was then asked by an officer who had had a lot of experience in helicopter-fitted frigates during their refits. He asked why the 'Air World' did not take more interest in the progress of frigate refits. The impression gained was that the flight disembarked before the refit started and no more was heard of it until the closing stages, when it demanded all support systems to be fully operational having taken no interest in them during the refit. The feelings expressed were noted and would be discussed with the Fleet authorities concerned.

SHIP MANAGEMENT SYSTEMS

The Ship Upkeep Management Systems (SUMS)

Commander Easlick of the Ship Maintenance Authority said that the Ship Upkeep Maintenance System (SUMS) has been designed as the successor to the Standard Documentation System for first installation in Type 21 frigates and Type 42 destroyers; later on it will be installed in the CAH and in the Type 22 frigates. The functions of the Standard Documentation System have been modified and extended in that SUMS will:

(*a*) enable the ME, WE, and Operations departments to plan their preventive and corrective upkeep work using similar procedures and a common central display. Maintenance planning will be co-ordinated on a ship systems basis;

(*b*) provide a means whereby these three departments can allocate. control and report this work;

(*c*) take full account of the introduction of the Job Information Card as the basic work instruction for all preventive maintenance and cleaning and for some corrective maintenance;

(*d*) provide a more convenient and efficient engineering data library.

The Need for a Change

In 1972, the Director of Fleet Maintenance was directed by the Naval Material Management Board to co-ordinate the onboard aspects of upkeep management in the Type 21 frigates and the Type 42 destroyers, and to produce an upkeep management system which was compatible with all the management developments known to have an impact on these ships. Details of these can be found in current DCIs and Fleet Technical Orders. Developments in the management of *Leander* Class frigates in recent years led to the conclusion that upkeep work of the operations department should be managed using the same sort of management aids as those used by the engineering departments.

In 1972, a directive was issued that the Type 21 frigates and the Type 42 destroyers should 'evolve towards a systems organization for maintenance in order to increase efficiency and conserve manpower'. On a lower plane, the old master record had been declared both cumbersome and inefficient. Work study and trials had proved that an equipment filing system was a better bet. Finally the SMA has received complaints from the Fleet regarding the shape, size, and format of the old style documentation.

SUMS

The differences between the old system and SUMS are:

(*a*) Upkeep Master Plans (UMPs) replace the Ship Equipment Lists, the Maintenance Schedule Volumes and Master Plans of the earlier system. The UMP does approximately the same job except that equipments and maintenance are grouped by ship systems instead of by trade or specialization.

(*b*) An Upkeep Display comprising a number of display units replaces the E2 planning racks. A notable difference is that the display axes have changed to allow planning by ship systems and there is now an 18-week time-base which is triggered by the monthly reissue of the ship longcast. The effective area of the display has been increased to allow the operations department to include its work on a common plan.

(*c*) The working documents are Job Information Cards for preventive maintenance, painting, cleaning, and some corrective maintenance, plus job cards and modification and A. and A. cards of the type now used in all SUIS adopted ships.

(*d*) Ship equipment files replace the master record.

Maintenance Management by Ship Systems

Over the past six months the SMA in close consultation with H.M.S. *Amazon* and H.M.S. *Sheffield* and to a lesser extent with other ships of these classes has developed a set of ship system definitions for each class of ship. These definitions range from the more obvious main propulsion system, main power generation and distribution system, and main weapons systems down to convenient groupings of equipments such as test equipment and office machinery. Having reached the agreed system definitions, the SMA then asked each ship to allocate the responsibility for the co-ordination of the work of each ship system to nominated departmental systems co-ordinators. In the ship, each systems co-ordinator will be given his own upkeep master plan (UMP) containing the maintenance schedules and bring-up documentation for each ship system for which he is the co-ordinator.

Ships may nominate as many systems co-ordinators as they believe necessary and may allocate systems between co-ordinators as they think proper. Let it be assumed that the WE systems co-ordinator is responsible for the main power generation and distribution system and that he wishes to plan the next month's work. His UMP will contain, between one pair of separators, all the maintenance schedules for all the equipments making up the system. In our example, this would include the main electricity supply system, the main generators, the diesels, the diesel air start system and the ready-use fuel tanks. In addition, there would be a set of planning sheets indicating what work was due in each month on the total system. Using this information, the system co-ordinator obtains the corresponding display planning cards and, in consultation with the appropriate specialist maintainers, plans the month's work for the whole system on the upkeep display.

The next stage is the weekly allocation of work. In this instance, the work controller, who may or may not be the same man as the system co-ordinator, extracts the planning cards for the week's work on a system and, again in consultation with the specialist work controllers, issues to the actual maintainer the working documentation and any instructions about need for co-ordination of effort with other maintainers.

It is important to note that, although encouraging the consultation essential to the systems approach to maintenance management, SUMS does not impose any constraints on laid-down responsibilities for professional engineering standards or actual maintenance. For example, in the case of the WE co-ordinated main power generation and distribution system, the ME work controller still allocates and supervises the work on the ME side of the generator couplings.

The SMA have recognized that different ships with officers or senior ratings of different technical backgrounds will wish to allocate and reallocate systems co-ordination responsibilities in different ways. The SUMS documentation has been designed so that systems can be transferred easily from one UMP to another and necessary changes elsewhere can be made with minimum effort. Once finalized, however, it will not be easy to change system definitions which must remain consistent throughout a class of ship.

Progress

The first SUMS installation is planned for H.M.S. *Amazon* in April 1974. Her ships's staff have been given short courses at the SMA in operating the system and now have written instructions. After a three-month's evaluation period in *Amazon,* the design of SUMS will be finalized and the final edition of the operating instructions will be published in BR 1313, the *Upkeep Manual.*

Progress with the Ship Upkeep Information Systems (SUIS)

Commander Thomas of the Ship Upkeep Information Centre (SUIC) said that the proper running of any business requires that management has the necessary information to enable it to make the right decisions. This need applies to all levels from the Board of Directors down to those actively engaged in line management. In this sense, the Royal Navy is a 'business' and has, therefore, a total 'management information' need covering all its activities. The Ship Upkeep Information System (SUIS) is that part of the total need related to upkeep. There are complementary information developments taking place in areas of finance, stores, and manpower.

Introduction

To provide information in the upkeep field, the SUIS attempts to measure the cost of that upkeep and the return for the expenditure involved. The costs cover manpower, materials, spares and stores expended by ships, by support agencies such as dockyards and FMGs and by contractors. This area takes something like 40 per cent. of the Naval Vote; a large sum by any standard and one about which information on detailed expenditure is essential.

The return achieved from expenditure on upkeep is a complex matter to assess; one of the best measures of the dividend, however, is availability. SUIS seeks to provide a more up-to-date mechanism for obtaining data on the reliability and maintainability of systems and equipments for aggregation into useful information about availability of systems, fighting capabilities and even whole ship roles.

SUIS can thus be regarded as a balance by which the cost of upkeep can be weighed against the results achieved in terms of usage, availability, maintainability and reliability. By making such comparisons at various levels, cost information can be used to assist in making decisions in the support field.

The System

Any information system consists of input, output, and data processing (FIG. 8). The problems of the latter are appreciably reduced by using modern techniques. Data is collected and the processing controlled by the Ship Upkeep Information Centre (SUIC) at Gosport. Although there is no computing facility at SUIC, a terminal on Bureau West is to be installed in 1976.

The difficult task has been the definition of output requirements by the various customers. Effectively, individual departments have been asked to say what they will require from the SUIS. Thought has, therefore, had to be given not only to the interpretations possible from available data but also to information needs. Information alone will not change anything: it is reaction to information that can produce beneficial change.

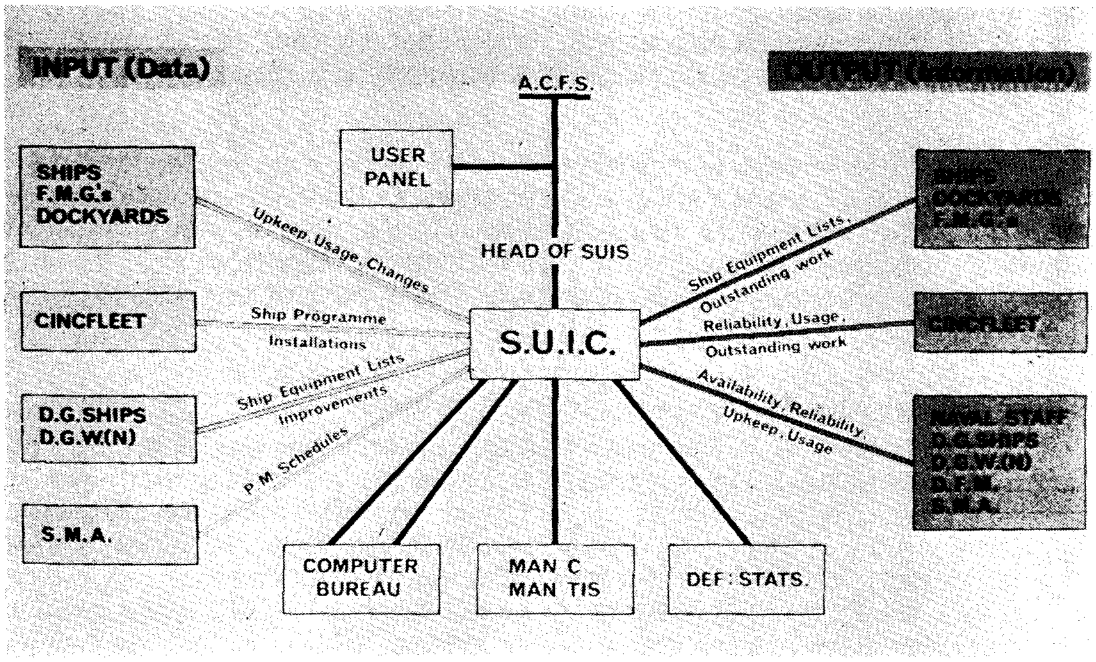


FIG. 8—AUTOMATIC DATA PROCESSING AND MANAGEMENT

One of the major customers of SUIS is the Ship Maintenance Authority. It should be emphasized here that SUIS in no way supersedes the SMA: the two activities are entirely complementary. It is part of the SUIS task to collect and process data so that the SMA is relieved of this operation and can devote its resources to technical analysis of problem areas. Their vital task of controlling the planned maintenance will also be assisted by outputs from SUIS on completed planned maintenance operations. There is close co-operation between SUIS and the SMA, and the future could possibly see them co-located.

Definition of the output requirement has determined the required input. This is collected in a variety of forms at the SUIC from ships, support groups, headquarters departments and eventually dockyards and contractors.

Reference to input from ships will, no doubt, raise the general concern felt about the increase of paperwork for ships' staffs. This is appreciated and, to this end, the Upkeep Management Department of the SMA considers all SUIS proposals to ensure that ships are not flooded with data collection requirements. Certainly SUIS needs to be given more information than has been provided in the past. Every effort has, however, been made to keep this within bounds by emphasis on two important features:

(*a*) Whenever possible, collection of facts should be an integral part of the ships' own internal management system.

(*b*) Facts should be reported only once. Once SUIC holds the fact, it should be able to process it into the various forms that customers require, e.g. analysis of the ME night rounds reports enables SUIC to produce the information previously acquired from the machinery running returns and the annual fuel expenditure returns, and also to calculate or infer the usage of some 240 equipments.

The normal internal management processes of a ship generate a great deal of information some of which in the past was discarded. SUIS, as a matter of principle, retrieves data by collecting documents being used in the Ship Upkeep Management System (SUMS). The items collected are:

(*a*) The job card, a four part card on sensitized paper the 2nd and 4th copies of which are direct punching documents.

(*b*) The 'yellow sticker' from planned maintenance operations. This is attached to the job information card on issue and transferred to a collecting sheet when completed.

(*c*) The modification and A. and A. record card which is also in four parts similar to the job card.

The relevant portions are returned to SUIC weekly with the ME night rounds report, machinery start/stop record and the elapsed-time meter record. Data is also extracted each month from the ship activity return.

These data documents are given a clerical check to minimize rejections during processing and sometimes a technical check to reconstruct areas where data has been omitted. Although the data capture rate is difficult to assess, it is believed to be reasonably good; the 18 *Leander* Class frigates using the system produce a total of about 1500 corrective maintenance cards and 1000 planned maintenance returns per week. Thus there is a considerable amount of data flowing into SUIS and certain outputs can now be made: there are 35 available outputs out of 50 outputs projected. A small sample of these includes:

Analysis of upkeep events by equipments
Summary of defects by fleet population
Summary of defects by ship population
Manhours expended on planned maintenance by ships
Ship equipment list
Mean downtime for failures
Mean repair manhours for failures.

The Future

The next two years will see the extension of SUIS with the installation of SUMS in the Type 21 frigates and the Type 42 destroyers as they complete, the inclusion of the remaining *Leander* Class frigates at present refitting, DLGs 05–08, the Type 81 frigates and possibly the Type 12 frigates. It is also intended that SUIS should supersede the Maintenance Identification and Defect Analysis System (MIDAS) which is run commercially for nuclear submarines. As ships with less than five years expected life will not be included, it will be at least that length of time before the whole fleet is using the SUIS. A very large area of data and information exchange with the dockyards is also under discussion at the present time.

As it is as yet early days for SUIS, the direct benefits are difficult to assess. Attempts can be made to cost these benefits in terms of money, but such a task requires the very type of information which SUIS itself seeks to provide. As the ship population grows, the real benefits will appear when problem areas can be highlighted in a precise and numerate manner so enabling effort to be applied to improvements in the areas where the greatest returns are available.

SUIS is an ambitious system with plenty of potential. Its success depends on two overriding factors:

(*a*) The quality of the input. Here, SUIS depends on the goodwill of those producing the data.

(*b*) The confidence level that management can allot to the information and its relevance to their business.

Now that some outputs are available, a reappraisal of the usefulness of these and other potential outputs is being made by those concerned. The User Panel chaired by the Director of Fleet Maintenance is at the centre of this activity.

Developments in Ship Reporting and Post-design Support—The Reliability/Maintainability/Logistics (RML) Systems

Commander Martin of the Ship Maintenance Authority opened by saying that the advent of the computer as a tool of management has made it necessary to consider carefully whether the Royal Navy needs to utilize its potential, and if so how best to do so. It is becoming clear that, although computer outputs need to be carefully examined by professional officers, these outputs if properly integrated can aid the decision making process.

Introduction

Efficient support of the fleet cannot be achieved without adequate management which in turn depends on adequate information and communication. There are two methods of producing information, namely: professional opinion, and the collection of numeric data.

Professional opinion with its wealth of detail must always be valuable. Indeed, if reference is made to a large enough aggregate of material, an individual observer may see enough events to have a reasonably valid opinion, whereas within personal experience he is often unable to observe enough events to form a valid opinion at detail level. Unfortunately, it is at detail, often component, level that design or modification actions have to be defined. In consequence, areas exist in which only data collection can produce valid evidence on which to base management decisions.

There are two possible approaches to deriving data. One school says, 'Decide what you need; go out and get it'. This has been tried with no great success. The other school says, 'Find where the potential data exists; do what you can with that'. It is this latter area that holds most promise and valuable experience has been gained in this field in the last few years.

The approach to deriving data is strongly influenced by the way in which one attempts to derive information from numbers. There are two methods of approach:

Cardinal Approach. The simplest way is by using numbers in a cardinal manner, where an exact count of absolutely complete and correct data is required and the totals that are derived are compared with specified standards. Judgements are made from the extent of departure from the standard values. The inherent difficulties in this method are those of laying down the correct standards, together with the greater problem of deriving adequate data to support this approach.

Ordinal Approach. Numbers are used only to place things in a relative order in a list. Attention is then drawn to the worst group and resources can be concentrated in this area. It can be demonstrated that relatively unsophisticated data can be sufficiently stable to make this approach valid.

The RML System

To make better use of information in the upkeep field, the Reliability/Maintainability/Logistics (RML) System has been developed. This has been described in DCIs T539/73 and T724/73 and in articles in the April issue of the *Naval Electrical Review* and the December 1973 issue of the *Journal of Naval Engineering*. Briefly the system sets out to:

(*a*) use ordinal information to enable resources to be concentrated on those equipments which most down grade availability;

(*b*) provide a guide to the investigator on what information is available to aid his judgement at detail level.

The RML system also meets many of the needs of the Director of Fleet Maintenance in distilling information to the Chief of Fleet Support (and has provided a central framework against which the management information needs to be considered). The system has so far been fed principally from two sources:

(*a*) A computer assisted analysis of job cards. This which is mainly aimed at defect analysis has been conducted for the last six years by the SMA. It is to be joined and blended with the SUIS analysis which aims to yield cost information.

(*b*) Discursive reports such as, S2022, trials and inspection reports, feedback from line overhaul, etc.

The outputs from the RML system provide information to the Director of Fleet Maintenance on shortcomings which lead to losses in availability. He may take action within his own sphere or invite action by other departments such as: DG Ships, DGW(N), DGST(N), training authorities, etc. A further type of output is design data to design authorities.

The outputs so far described arise from deliberate acts of reporting and this inevitably imposes additional effort for the purpose of obtaining data. However, there is another source of data which is largely untapped. This source is the considerable amount of written communication produced during the normal processes of line management for purposes such as requisitioning material or services. If these records can be tapped (after they have achieved their management purpose), three special features result:

(*a*) The record is necessary to cause activity to take place.

(*b*) Management has an active interest in the existence and accuracy of the record—they cannot manage without. The records are also often subjected to ADP.

(*c*) Data is derived by metaphorically shaking out the management waste-paper basket, i.e. without incurring additional recording effort.

Thus: naturally occurring information can be derived from line managers (such as, CED and DGST(N) and from the Ship Upkeep Management System (SUMS)). Maximum use should be made of this potential, where appropriate by asking line managers to run special programmes on their own ADP, feeding the results to more central ADP areas. Of course, the managers will produce information aligned to their own needs and there are translation problems, but it may thus be possible to reduce to a minimum the requirements for specialized data collection.

One gap in ship reporting relates to the jobs undertaken immediately under operational pressure. In these cases, the prime motivation quite rightly is to 'fix it' rather than report it. To try to obtain information in this area, DFM(SMA) has started a liaison with the Operational Evaluation Group (OEG) by which it is hoped that, when exercise logs are analysed, the more significant material shortcomings will be highlighted.

Studies made during the development of the RML system have led to a more coherent concept of management information. It has been realized that cardinal information exists at top level in the form of defence estimates. Nothing enters the naval service which is not at some time represented in some part of these estimates.

It is theoretically possible to trace the cardinal quantities as progressively smaller aggregates of money or material downward towards the point at which a final traceable aggregate is dispersed and applied to a service. At the same time, it is unlikely that data collected at low level will ever be sufficiently complete to be used in a cardinal manner, i.e. to add up to the lowest traceable cardinal aggregates descending from the defence estimate. However, by collecting data at working level, preferably through the records inevitably produced by line management, it is possible to obtain stable ordinal estimates of the manner in which the aggregates are dispersed. Taken together, the combination of cardinal information from the top and ordinal information from the bottom provides good estimates to guide relevant decisions.

Summary

Efficient fleet support can only be achieved by total management of a wide range of factors, many of which are reported from ships. Although ships' officers recognize the need for reporting activities under their direct control in ships, they do not readily recognize their potential influence over less direct activities occurring elsewhere and which can be just as important to fleet support. A lot of information is engendered in normal line management procedures, and this must be disseminated more widely to achieve the best use of the resources available.

Discussion on Ship Management Systems

The impression was prevalent in the fleet that the introduction of SUMS would further confuse those in ships. No clear objective had been given to ships on exactly what information was required of them. The panel said that it should be remembered that SUMS was being introduced to help the management of ships and that it had been based on comments from sea as well as on the need to acquire a wide range of information.

A proposal from the audience was that AMP management would be more efficient if FMG work was defined in standardized packages. It was suggested that this should be a part of SUMS. The panel agreed this concept is feasible and promised to look into the proposal in more detail.

A complaint was made about the different but related information required from ships, for instance: Which document defines the configuration, is it the ship equipment list or the ship account? How are the two updated? It was admitted that many different information retrieval systems had been developed historically by different departments, and there was a pressing need to integrate them. This was a long and time-consuming business.

A questioner asked when SUIS would make its first cost calculation, and how much the making of this calculation itself would cost. It was not known when SUIS would make such a calculation; a close and constant watch, however, was being kept on SUIS costs.

To a further question, it was stated that guarantee work was still reported on as before, as SUIS reports are only required for equipments accepted by the MOD.

DOCKYARD SUPPORT FOR THE FLEET

Rear-Admiral Griffin, Director of Dockyard Production and Support, spoke of the finance involved in operating the dockyards; of the role of the dockyards in supporting the fleet; of the control procedures for allocating resources; and finally of the development of facilities in the four home dockyards.

Scale of Operations

The dockyard programmes account for a sizeable share of total naval expenditure. In the last financial year, out of some £818M voted for the Navy, just over £130M was allocated for dockyard programmes. This was divided about equally between wages and salaries of personnel and the various material inputs of stores and ship and weapon equipments.

Total dockyard expenditure just about equals new construction costs. Thus, every penny spent in the dockyards means so much less for the new construction and weapons programme. With the present financial squeeze, a reduction in the new construction programme means more dockyard effort; if a new ship is cancelled, the dockyards get another refit—and of an old ship at that. Demands on the yards should be reduced to the minimum necessary.

Forms of Support

The forms of support provided by the dockyards to the fleet are as follows:

OPDEFs	—	Emergency repairs to preserve operational and seagoing efficiency.
DAMPs	—	For CVAs and LPHs at regular intervals so that defects beyond the capacity of ships' staff can be rectified.
Pre-deployment AMPS	—	For ships before deploying abroad for up to nine months.
DEDs	—	At about mid commission when all essential underwater defects, including some planned maintenance items and other essential defects which cannot be left till the next refit, are rectified.
Normal refits	—	Ships are maintained with a view to returning in a suitable state for about three years service with the fleet. The cost of a frigate refit is about £1M and that of a SSN is about £9M.
Major refits	—	These occur at about half life, when ships require complete overhaul and some degree of modernization. They are both expensive and complex—H.M.S. *Hermes* recently took $2\frac{1}{2}$ years and cost £$23\frac{1}{2}$M.

Major refits, normal refits, DEDs and DAMPs are all programmed periods the dates and timings of which are agreed by Naval Staff and CED. As such they have budgets in man-weeks and labour is allocated in the respective dockyards' programmes. However, the work for OPDEFs and pre-deployment AMPs, although unprogrammed, is an integral part of the dockyard task and allowed for on the basis of past requirements.

Resource Allocation

There are too many problems in operating the dockyards to mention them all here. Two, however, which seriously affect the ability of the dockyards fully to support the fleet are:

(*a*) The current difficulty in obtaining materials and spares due to world shortages and to the recent industrial strife. Steps are being taken centrally by CFS to conserve material and to give priorities for its allocation.

(*b*) The labour shortages due to a gradual run down in numbers of craftsmen, and a reduction in expertise due to an increasing turn-over rate. The problem is exacerbated by the increasing requirement for those tradesmen who are most difficult to recruit, i.e. mechanical and electrical fitters, coppersmiths and boilermakers.

The labour problem results from the MOD not paying as well as some local firms. Action is in hand to introduce a new wage structure but, even when approved, it will take some time to reverse the run down. Meanwhile, the dockyards lack the capacity necessary to support the fleet fully. Because of the current financial stringency, it is unlikely that this can be overcome by buying help from private industry.

For this reason, it has become necessary to devise a scheme to ensure that the capacity that does exist is used to the best advantage of the fleet. This scheme, which is called Dockyard Resource Allocation Control Procedure (DRACP), is about to be promulgated by DCI. Each ship due for refit in the next ten years is allocated a budget figure in man-weeks, such that the aggregate of all budgets for each year equals the anticipated total dockyard manpower capacity available for such deployment.

The Naval Staff issue a ship planning budget some time before each refit. The time of issue varies from 33 months before start date for nuclear submarines and other major refits to 12 months before start date for normal refits. After issue of this budget, the figure is refined by the Dockyard from knowledge gained from the pre-refit visit and by Fleet Staff from knowledge acquired from operating the ship (FIG. 9). The ship budget is then issued and the Dockyard Project Manager with Fleet Staff negotiate the work package to the smallest necessary to achieve a satisfactory refit. If, to

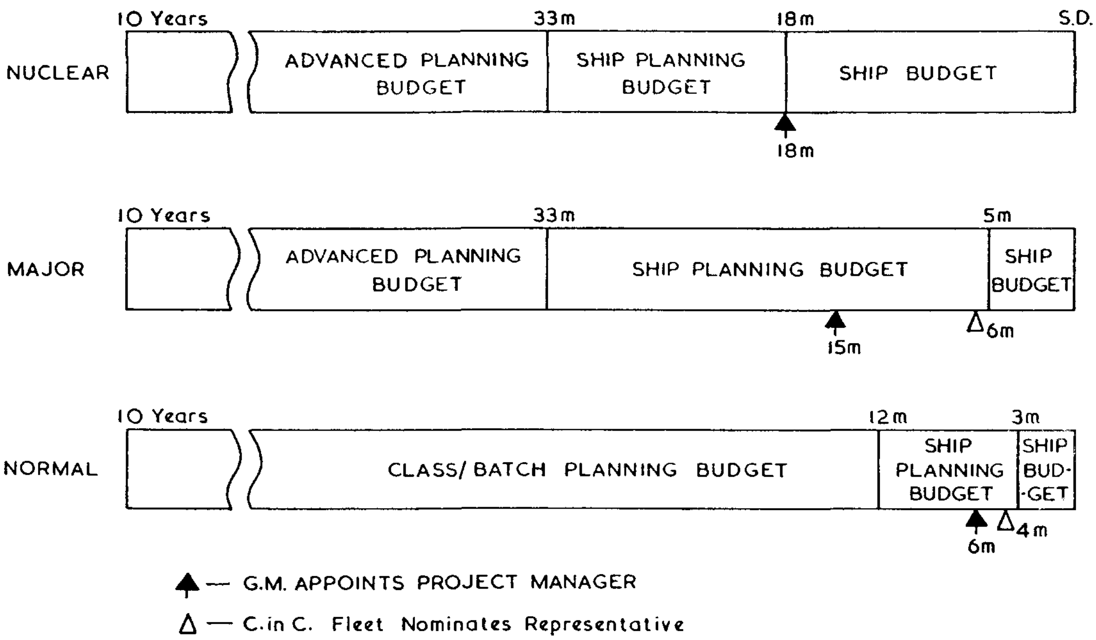


FIG. 9—DOCKYARD RESOURCE ALLOCATION CONTROL PROCEDURE (DRACP)

undertake essential work, an increase in the budget is required, MOD approval is necessary. After start date, the budget will never be increased. Any overspending will be a measure of the failure of the Project Manager and Fleet Staff to forecast the correct work package and is likely to result in penalties to other projects.

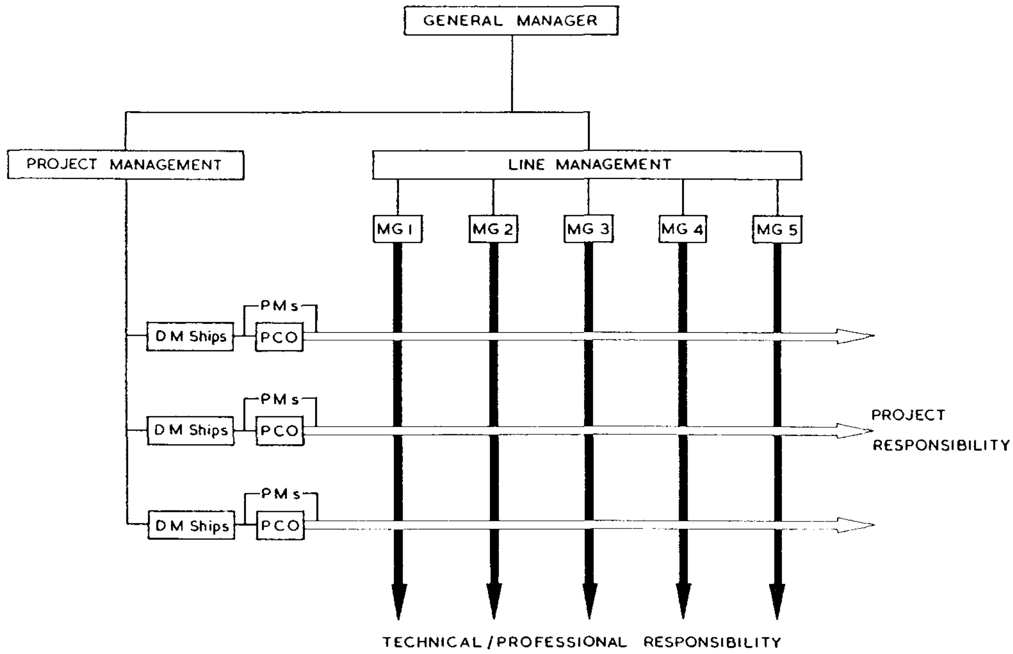
Specific times are laid down for the appointment of Project Managers and fleet representatives who will work closely together. Some work may be delegated to the staff of the local CSO(T).

Project Management

The dockyards are the object of conflicting criticisms. From one quoted naval point of view, dockyard workers appear disorganized, uninterested and lazy. From the trade union side, dockyard workers complain that they are under-employed and are losing potential extra money on bonus schemes. While from the dockyard managers (many of whom are naval officers), the complaint is that the yards are overloaded and cannot complete refits on time.

Each point of view has some truth in it, inevitably so in a jobbing warship repair organization. It is only possible, however, to provide the detailed planning and control effort and material support required for one or two continuously highly manned ships in each yard. This is done for SSBNs, SSNs, aircraft carriers and other special priority ships. The rest have reduced manning with a time allowance built in for dealing with unforeseen circumstances. This allows men to be moved from one job to another and so reduces the wastage which would result if the projects were more highly manned to a tighter schedule.

In other words, there is no point in manning up to shorten a critical path unless it is possible to service the workforce with spares, material and information, and to protect it from disruptions. This can only be done for a few high-priority jobs. Nevertheless, refits must not be allowed to drift to the right for lack of pressure. To this end, a project management system



THE PROJECT MANAGER WILL BE THE MOST JUNIOR OFFICER IN THE ORGANISATION WHO WILL BE CONCERNED WITH <u>ALL</u> FACETS OF THE PROJECT.
HE ESTABLISHES THE BROAD STRATEGY, MONITORS THE PROGRESS OF WORK AND INTERVENES WHERE NECESSARY.
HE DOES NOT HAVE EXECUTIVE CONTROL OF PRODUCTION WORK AT ANY STAGE.

FIG. 10—MATRIX STYLE PROJECT MANAGEMENT

which is standard across all yards has been installed to ensure that the pressure is maintained.

This system makes one officer concerned with all aspects of each project from start to finish—from the pre-refit planning activities until the completion of the refit. He co-ordinates the activities of all the trades to ensure that the schedule is maintained or that the best compromise is effected by rescheduling. The line officers, in direct charge of the work force, are responsible for quality, cost and timely completion of their elements of the work package. This system is known as project management on the MATRIX style (FIG. 10).

The project manager is the contact officer both for the ship and for all authorities outside the yard, and all work to be taken on must have his agreement. Progress meetings will normally be chaired by him and refit reports will be made by him in consultation with ships' officers.

Project managers have already been appointed to the more important projects, and second and third level planning staffs are being housed in project control offices to ensure that the pre-refit and production planning actions are brought together. This ensures that the project manager's plans have the support of the line and enables him to control any rescheduling that might be necessary.

It is hoped that this scheme will improve the leadership of the work force. The project manager's place is onboard, encouraging the men whom he should get to know well.

Development of Facilities

An extensive development programme has been started to update the major production shops of the dockyards and to provide specialized refitting facilities for particular classes of ships typed to individual yards. The programme being planned is the most ambitious development scheme for dockyards since before World War I; its extent and time-scale may, however, be altered by the outcome of the current Defence Review.

At Devonport, the plan includes:

(*a*) The pipe shop which replaces the mechanical and constructive coppersmiths' and plumbers' shops is scheduled to complete late this year.

(*b*) North Lock development. In 1970-1, North Lock was divided into two to provide two docks for SSN DEDs. All necessary support facilities for docking of nuclear vessels are being provided.

(*c*) Frigate Complex. A major project to provide grouped facilities for refitting frigates was started in 1972 and should finish in late 1976. This involves the extension and modification of Nos. 5, 6 and 7 docks, building the necessary support buildings, and covering the refitting docks.

(*d*) The plate-working shops are to be rationalized.

(*e*) The Nuclear Complex. This is the largest single project, and involves the construction of two new refitting docks at the north-west corner of No. 5 basin with all the specialized refitting and refuelling facilities for nuclear submarines on the peninsular between the docks. Site work is now in hand to a very tight time-scale to enable the facilities to be in service by 1979.

(*f*) The joiners shop is to be extended and modernized.

(*g*) Nos. 8 and 9 dock areas are to be redeveloped to provide full refit support facilities to modern standards.

At Portsmouth, the main items are:

(*a*) The amalgamated pipe shop is due to complete this year.

(*b*) The heavy plate shop replaces the old boiler shop.

(*c*) The facilities around No. 2 basin in support of conventional submarine refitting are being improved and this is due to complete this year.

(*d*) The afloat support facilities in the 'C' and 'D' lock areas and at No. 8 berth in No. 3 basin are being improved. This is nearing completion.

(*e*) No. 3 basin and Nos. 12, 13, 14 and 15 docks are being redeveloped to provide comprehensive facilities for the refit support of Type 42 destroyers and DLGs.

(*f*) The dockyard extension outside the Unicorn Gate is being built to include a new M/T vehicle complex, an apprentices training centre and a new chart depot, as well as the general development of roads in the area.

At Rosyth, several further major developments are planned following the major nuclear refitting developments of several years ago. These are:

(*a*) The synchrolift and small ship refitting complex will replace the three elderly floating docks in which much of the MCMV and smaller craft refitting is carried out at Rosyth at present. The synchrolift platform will be capable of lifting ships of 1000 tons displacement; these will then be transferred on a rail system to one of the five covered refitting bays which, with all their support facilities, will be sited to the west of No. 1 dock.

(*b*) The nuclear refitting dock area will be improved. Many lessons have been learnt since this area was redeveloped five years ago; and a number of detailed improvements and extra stores and facilities to replace the existing LSTs which are used in support of SSBNs refitting are planned.

(*c*) The main workshop bays are to be further rationalized to provide a more efficient and logical grouping of work.

At Chatham, approval to plan a development programme has only just been received and a plan has therefore yet to take shape. Proposals are expected to include a major facelift for the main engineering factory and a very considerable redevelopment of the support facilities adjacent to the non-nuclear docks and refitting berths.

This modernization work will bring disruption in the wake of the major developments; such is already the case at Devonport and will affect all yards for some time to come. This, however, is the price that must be paid for the sake of the future improvements in the capabilities and capacity of the dockyards.

Conclusion

The dockyards are not only an integral but are also the largest part of the naval bases and are inextricably concerned with the upkeep of the fleet. The well-known national problems associated with the employment of industrial labour equally affect the dockyards. However, a deliberate policy by both ships' officers and ratings of taking an interest in the workmen will pay off in greatly needed higher output; senior ratings should set out to know all the men working in their part of ship during the refit, and officers should not fail to recognize when a good piece of work has been done. This would not only help the ship concerned but would also bring people to enjoy working for the Navy, and so reduce the present efflux in large numbers from the dockyards.

Discussion on Developments in Dockyard Support for the Fleet

A questioner suggested that refit planning should be based on the work load and not on what can be done in the time available. The reply was that, for ahead planning, this was not practicable and that the work which the dockyard could undertake had to be rationed out on a basis of past experience.

It was suggested that, as the fleet was getting smaller and that the refit intervals were getting greater, the dockyards should be reducing rather than expanding. It was pointed out that the lengthening of the intervals between refits resulted in more work at the refits.

Admiral Griffin, when asked what caused the main disruptions of dockyard loading, replied that the main causes were changes in the fleet programme, unforeseen work arising mainly after the start date of the refit, and also to an imbalance of trade numbers.

Some members of the audience felt that dockyard workers were apt to be confused about to whom they were responsible and that the new Matrix system would confuse them still further. It was replied that the new system was intended to allow the professional line managers, while being co-ordinated but not controlled by the project managers, more scope to concentrate on maintaining and raising the quality of work. At the same time the project managers could ensure that the programme was maintained. It was pointed out from the floor, however, that the Matrix system still has to be tried and proved in detail.

FLEET MAINTENANCE BASE DEVELOPMENTS

Commander Hall-Hall of the Directorate of Fleet Maintenance said that a Fleet Maintenance Base could be conveniently described as the physical establishment at which uniformed personnel are employed to provide ships, submarines and craft with assisted maintenance. It houses a Fleet Maintenance Group (FMG) comprising one or more maintenance units and is designed to provide support facilities, berths and the services needed to allow ships in maintenance to shut down most of their machinery.

Evolution of Fleet Maintenance Units (FMUs)

Maintenance units have evolved since about 1955 when, except during refit and docking periods, the surface fleet was essentially self-maintaining, having complements large enough to be able to cope with the planned maintenance and the majority of the defects of the comparatively simple equipment. Although assistance was given by repair ships, this was mainly for the smaller units such as ocean minesweepers. It was, however, beginning to be recognized that larger ships also required help with routine tasks and some measure of assistance was obtained from the training ships attached to artificer training establishments.

By contrast, in the submarine flotillas the picture was very different as it had been recognized for a long time that submarines were not self-supporting. Whenever boats came in for maintenance they could expect the services of the depot ship or base; depot ships at Rothesay, Portland and Malta were complemented to meet this task as was H.M.S. *Dolphin,* the one major submarine shore base.

In 1958, Portland became the support base for six Type 14 frigates which from the design stage had been recognized as dependent upon shore support. A frigate maintenance unit was formed and this, together with the gradual creation of FMUs from the overbearing of artificers at the home ports, formed the basis of the fleet maintenance groups we know today.

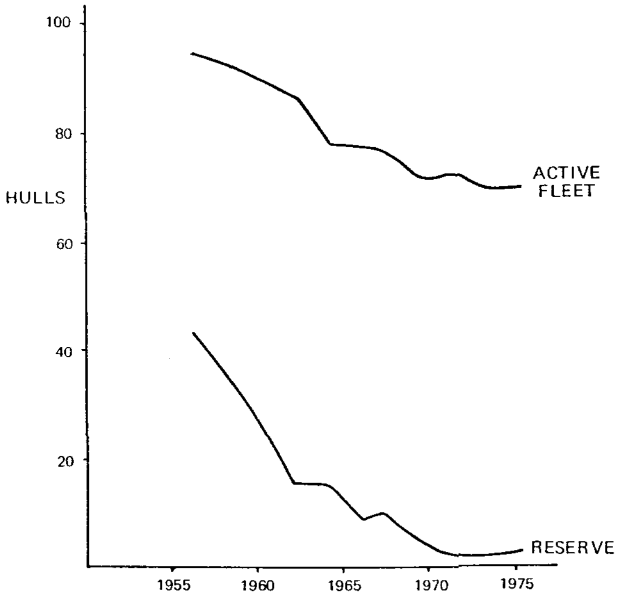


FIG. 11—DESTROYER AND FRIGATE HULL POPULATION

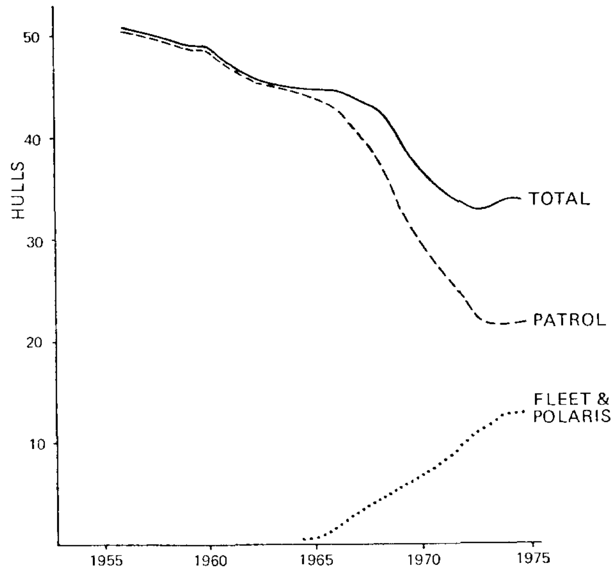


FIG. 12—SUBMARINE HULL POPULATION

In 1959, it was accepted that all destroyers and frigates had insufficient ship's staff maintenance effort and two years later approval was given for a balanced team of officers and ratings to assist ships during their maintenance periods and refits. To allow for 25 per cent. of the effort to be spent on end-of-refit trials, six teams were complemented, each initially sixty-four strong. However, as ships became more complex more help was needed. Complexity though was not the only reason for the increased need; an era of enhanced cost-consciousness had brought the realization that the most expensive maintainer was the one borne afloat and this resulted in the tendency towards smaller ship's complements and so to still greater dependence on shore-based support.

FIG. 11 shows that the destroyer and frigate fleet has decreased from about 100 active hulls in 1956 to about 70 today. This contrasts with the FMG manpower total which has increased so that now, with practically all ships except *Ark Royal, Bulwark* and *Hermes* entitled to FMG assistance, there are 12 FMUs. Currently a complement of 84 ratings is recommended for each FMU and this now includes elements for ship husbandry and OPDEF rectification in addition to the normal assisted maintenance period (AMP) and end-of-refit tasks. The trend towards smaller complements for ships is likely to continue thus leading to an increased transfer of maintenance load to the FMUs and so to an increase in their complements.

The scope of FMU work is essentially confined to that which can be done by the ship's company. This aligns with the identification, accepted by the Way Ahead committee, of the FMUs as an extension of the ship's company and ensures that the deep craft expertise and facilities provided are not a duplication of those in the dockyards.

Despite the decrease over recent years of the number of hulls (FIG. 12), the submarine maintenance manpower has, like its surface equivalent, steadily increased. The reasons, whilst similar to those leading to increases in the surface fleet's support requirements, are strongly influenced by the introduction and increasing complexity of the SSNs and by the Polaris programme. FIG. 13 gives an estimate of the growth in the amount of uniformed

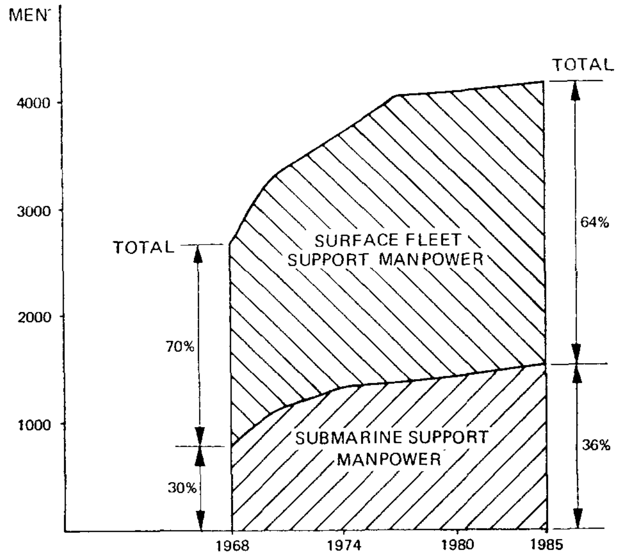


FIG. 13—GROWTH OF UNIFORMED MAINTENANCE MANPOWER

maintenance manpower, including all repair and technical staffs, and also shows how the proportion of this devoted to submarines has increased.

Current Developments at Fleet Maintenance Bases

In the sixties, a number of committees and working parties studied aspects of shore support and, in 1968, a recommendation of the Maintenance Support Manpower (MAINSUM) working party that workshops and facilities should be provided for the FMUs was accepted in principle by the Way Ahead committee. At much the same time it was decided to develop the Naval Bases, and the Fleet Maintenance Base requirements were ultimately incorporated into the resulting naval base development plans. Although adopting a uniform approach, the plans for each base are tailored to suit the requirements of the ships to be supported and to make the best use of the land and berths available. Bases therefore evolve on somewhat different lines.

Rosyth. In terms of timing, Rosyth is the most advanced redevelopment. The particular feature here is that the base will serve both as a maintenance base for frigates and as a combined operating and maintenance base for MCMVs. The major new facilities include: a new jetty, workshops, a canteen, FMG and MCM offices, stores, and specialist MCMV workshops. Much of the work, notably the jetties and services, is almost complete and the workshops and offices are also well in hand.

Devonport. H.M.S. *Defiance* is a combined surface ship and submarine base and, in addition to giving continued support to frigates and other ships and craft typed to the base, is being built as our second nuclear submarine operating base. The development plans are heavily influenced by the operating and support requirements of the growing number of SSNs in the squadron and this is reflected in the costs of the scheme.

The base is currently centred on the submarine depot ship, H.M.S. *Forth,* berthed at 8 wharf. She is due to be scrapped in 1976 and the new base, which is being constructed close by on the old coaling ground, will include 8 and 9 wharves as AMP berths for SSNs and 10 to 14 wharves, augmented by the planned Weston Mill Lake jetty, as frigate berths. FIG. 14 shows the layout of the planned base on the North Arm. The workshops and offices will be combined in one block which will also provide accommodation for the staff of the Captain, 2nd Submarine Squadron. Nuclear facilities, shared with the nuclear refitting complex, will include decontamination and effluent treatment plants, demineralized water plant, generators and a laundry.

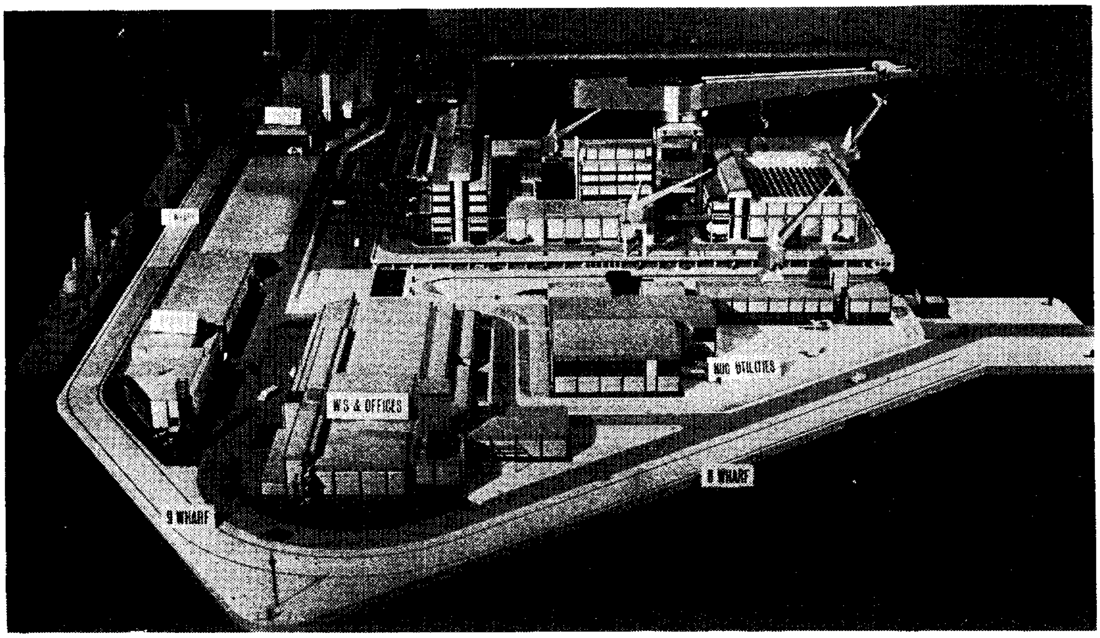


FIG. 14—LAYOUT OF PLANNED BASE ON THE NORTH ARM AT DEVONPORT

A major element of the cost arises from the nature of the site which was a tidal mud flat until reclaimed in 1905 with the rock excavated from No. 5 basin. As a result, special features have had to be designed into the building foundations to guard against possible differential settlement. The frigate AMP berths along 10 to 14 wharves are already almost complete. The boiler house, chilled water plant and support buildings will be sited opposite 10 and 11 wharves and a reserve area for future expansion will also be allowed for in the plan.

The cost of developments for the submarine and surface interests is split about two-thirds to one-third.

Portsmouth. Here the task will be mainly to support the DLGs, the Type 42 destroyers and the decreasing number of *Leander* Class and older frigates. The welding shop and No. 3 smithery, which currently houses the fleet maintenance group, will be demolished to make way for the new workshop and offices. 5 slip will be levelled and filled in. The vast No. 3 ship shop adjacent to the Middle Slip jetty, originally built in 1849 to provide cover for 3 and 4 slips and whose cast-iron structure served as a prototype for the Crystal Palace and the London railway termini, is planned to be demolished to allow development of the jetty.

The general plan incorporates a new cope-line extended on the south-west wall and all along the west wall. Most berths will be given the ideal requisites of a clear jetty, support buildings and service roads. There will also be areas reserved for future expansion.

Chatham. At this base the AMP task is diminishing and it is unlikely that any early development will take place in the fleet maintenance base although the existing facilities will be kept up-to-date and contingency plans laid for the future.

Hong Kong. Plans exist for updating the facilities for frigates and patrol craft.

Singapore. At Singapore the resident fleet maintenance unit is due to return home in August after which the fleet maintenance base facilities will be put under care and maintenance and re-activated when required by FMUs deployed from the United Kingdom. No development is planned at present.

Malta and Gibraltar. There are no plans for developing the small fleet maintenance facilities at Malta and Gibraltar.

Portland. Although not essentially a fleet maintenance base, some mention must be made of Portland. The development plan aims to effect a general improvement to both berths and facilities. The new workshops are complete and a new deep-water berth on Outer Coaling Pier, an extension to 'Q' Pier, and the reconstruction of Dock Pier are all planned.

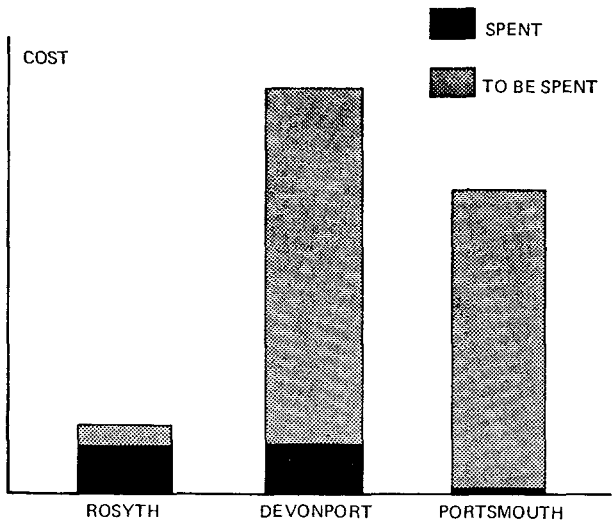


FIG. 15—SPEND TO DATE AND ANTICIPATED FUTURE SPEND ON MAINTENANCE BASES

Summary

Uniformed maintenance support from shore for the future fleet is a growing requirement. To provide the facilities for the efficient employment of this support, three major maintenance bases are being developed for the surface fleet. We are only at the beginning of the programme (FIG. 15).

Discussion on Fleet Maintenance Base Developments

The first questioner asked whether more thought could be given to FMGs doing the non-technical tasks such as painting and storing. The reply was that junior ratings had been made available for ship husbandry from overbearings but with manpower shortages these overbearings would soon disappear.

It was asked whether any thought had been given to using civilians for ship husbandry. This had been proposed on a contract basis, but no organization had tendered. It was also felt that this was an unnecessary duplication of civilian effort already available in the dockyards.

Some concern was felt that FMGs were not complemented to give support to frigates during refits, and it was felt that ships would never complete on time without this support. This was recognized as a problem which would increase with shortages of personnel. However, it was thought that the streamlining of the dockyard support organization during the latter part of refits could alleviate this problem.

The last questioner asked whether it was possible to have some method of informing the fleet of the skills available in different FMGs. The answer was that FMGs were staffed with the normal range of naval skills. Expertise would increase as ships were typed to different bases.

FINAL DISCUSSION

The main point raised during the final discussion was whether the refit work package control system used so successfully with the SSBNs could not be developed for the surface fleet. It was replied that, although the tight disciplines developed with the SSBNs had achieved good results, it had been at enormous expense in terms of manpower and effort. This system also depended heavily on extensive and tightly controlled pre-refit trials. It would be too expensive to apply such procedures directly to every ship.

It was also answered that expense precluded the production of standard AMP work packages.

CLOSING ADDRESS

Vice-Admiral Sir Allan Trewby, K.C.B., Chief of Fleet Support, in his closing address said that he had had to undertake many difficult assignments since becoming a member of the Admiralty Board, but he had never before had to make the closing remarks at a conference on the subject for which he had Board responsibility and from which he had been absent for virtually the whole time.

He apologized for his absence and said that it had been absolutely vital to attend a crucial Admiralty Board meeting that morning and that he had only avoided attending a second meeting that afternoon by special pleading to Ministers. The Board meeting had had relevance to this conference because it was on the subject of future Defence spending which (he was sure the conference was aware) was coming under even greater pressure than usual at the present time; with Fleet Support taking the largest slice of Navy votes (over 38 per cent.), it was very necessary to get the best brains of the engineering specialization focussed onto reducing support costs.

He was, therefore, most grateful to Admiral Raper for sponsoring the conference, to Captain Pillar and his staff for providing such excellent facilities, to Commander Bruce for all the hard work he had put in as secretary; and finally he thanked those officers who had presented papers or led the discussions.

Admiral Trewby continued by stressing the importance of support costs and also emphasized that the high proportion, which he had already mentioned, of the Naval Budget spent on Fleet Support takes no account of the pay and allowances of the R.N. personnel involved. He said that fleet support is probably the least glamorous of all naval activities but, although not well understood by many naval officers and ratings, is nevertheless vital to the operational efficiency of the fleet; unless its costs in manpower and material can be reduced, the Royal Navy will not to able to afford the new ships, submarines and aircraft with up-to-date weapon systems which it so badly wants.

Admiral Trewby went on to say that the main factors that determine support costs are:

(*a*) The quality of the original design and its state of development when introduced into service. This is the essential factor because, unless the design is good and the development is thorough, support costs will inevitably escalate.

(*b*) The mode of operation of the machine, weapon system or equipment, and the standard of training of the men operating it: although this is self-evident, maloperation and lack of technical discipline are still the cause of quite significant support costs.

(*c*) The policy adopted for the support of the machinery or equipment.

(*d*) The additions or modifications made to the original design after coming into service.

Naval engineer officers are involved in all these activities, the overall support bill for which at present amounts to £345M per year excluding the pay and allowances of uniformed personnel. These costs will only be reduced by better engineering skill and discipline at all levels.

Admiral Trewby said that he now wished to focus very briefly on a few aspects of fleet support, apologizing in advance for any repetition of what had been said in discussion. Firstly: as the effort that can be deployed in reducing fleet support costs is limited, the available resources must be channelled into the areas which will give the greatest possible reductions. To ensure this, the most effective upkeep information system that can be afforded must be developed. It must be stressed once again that such information systems can only be effective if they are fed with accurate, up-to-date inputs, and this requires technical discipline on the part of all engineer officers and ratings. Secondly: it is essential that the latest technology is applied to fleet support in all areas to reduce costs. In this connection, the Chief of Fleet Support is the Board Member responsible for support throughout the Royal Navy for surface ships, submarines and naval aircraft with their weapon systems. Over the years, each of these groups has developed different techniques and policies for support; and, although there is no intention of making them all conform in detail to a common policy, it is most important that proper liaison is maintained and, where practicable, expertise is transferred from one area to another. Thirdly: it is vital that fleet support policy should be as flexible as possible in an era of rapid changes. Taking new weapons, for example: none of the new generation of missiles or torpedoes coming into the future fleet can be maintained or even tested onboard. They all have to pass through RNSTS armament depots for servicing and testing, and this will almost certainly lead to changes in policy with, perhaps, a more formalized take over procedure by DGST(N) from the project in DGW(N).

Referring to the dockyards, Admiral Trewby said that the fundamental problem has always been how to develop a commercially efficient organization which is able at all times to meet the upkeep demands of an operational fleet. For industrial efficiency, the load must be tailored to match the capacity which is spread among some dozen different trades; to meet the demands of the fleet, the dockyards ought to have the flexibility to expand or contract or alter the balance of trades at short notice to meet the ever-changing work pattern and, in particular, to deal with emergency repairs: these requirements are mutually incompatible and yet, in practice, a satisfactory compromise solution must be achieved.

Several of the changes which have been introduced recently, such as Dockyard Resource Allocation Control and the Refit Reporting System, have been designed to improve the co-operation and understanding between the dockyards and the fleet, with the aim of obtaining the best compromise solution to the fundamental problem just mentioned.

On a more personal note, Admiral Trewby said that he was appointed about six years ago to put in train support facilities for this country's strategic nuclear deterrent. He was told that the project would have high, though not overriding, priority; but, on the other hand, it was made quite clear to him that breakdown of support must *never ever* occur. In the event, of all the Polaris patrols so far carried out, none has been aborted, and all SSBN refits have been completed precisely on time (to the day) and within the original estimates of cost. He therefore knew from Polaris experience that, given sufficient priority, manpower and money, a very high standard of fleet support can be achieved. The real challenge, he said, is to improve or at least retain the availability of the rest of the fleet while using fewer and fewer resources of manpower, money and materials.

Admiral Trewby finished by saying that engineer officers are involved directly or indirectly in every aspect of fleet support for the major part of their service careers. Therefore, *they* are the people who must rise to the challenge and, by greater professional competence and discipline, ensure that the Royal Navy's limited resources of money, manpower and materials are used in the most effective manner to support the future fleet; in particular, they must make certain that costly mistakes are avoided.