MANAGING DEPOT SPARES

BY

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The following article is the substance of a lecture given by the Author at Headquarters on the work of the Section (126) in the Technical Support Group which deals with Depot Spares for the Fleet. The Author is the Head of this Section.

Section 126 ceased being a Ship Section in October 1966, when, in its new role, it assumed responsibility for Depot Spares for the Fleet. Since that date, it has gradually taken over most Depot Spares from Engineering and Electrical Ship Sections and all Hull equipments for the Surface Fleet.

It has now been decided that being in essence a support section, we should be transferred from the Controller's Department to the Chief of Fleet Support. It is expected that in May next year we shall 'don our new hats' under Director-General Supplies and Transport (Naval) and will combine into one integrated section with our storekeeping friends of DGST 40B. We must remain closely associated with DGS and hope to take up residence in the 'B' Block extension now under construction.

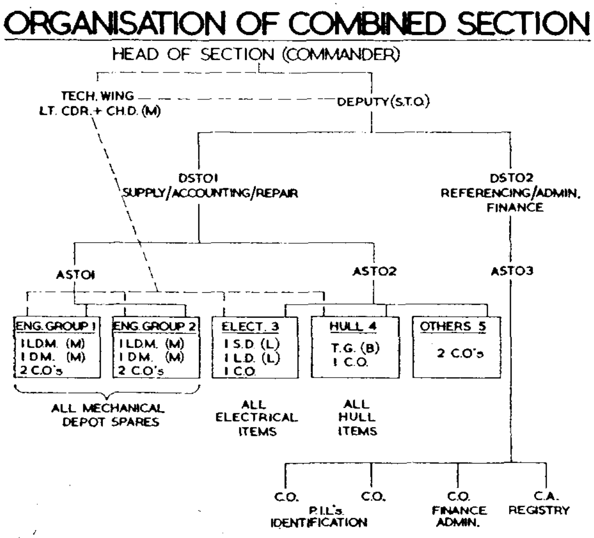

FIG. 1

FIG. 1 shows the possible organization after integration. Each working group with its responsibility for a specified range of ships and equipments will be jointly staffed with technical and non-technical personnel.

VALUE DEFINITION

A. LOSS OF AVAILABILITY, PERFORMANCE ETC. SAVED BY HAVING A DEPOT SPARE WHERE YOU WANT IT, WHEN YOU NEED IT

B. ADDITIONAL COSTS (EG. DOCKYARD OVERTIME, AD HOC REPAIR COSTS, CANNIBILISATION COSTS ETC) SAVED BY HAVING A DEPOT SPARE WHERE YOU WANT IT, WHEN YOU NEED IT

FIG. 2

In the light of these developments, it is not intended to dwell at length on our past achievements and failures unless they can be used to highlight areas of our activity needing improvement. We shall therefore concentrate on aspects of the future management of Depot Spares, laying particular emphasis on points which affect us all. The reason for this is because I believe that MOD(N) are poor managers and that we frequently have to make management decisions with inadequate guidance and most usually without sufficient information to provide a valid basis for those decisions. We are then forced to live with the wrong decisions that we and our predecessors made. We must aim to manage better in the future.

This might be a good time to quote a couple of bad decisions:

(*a*) Of the smaller depot spares purchased in the 1950s, there are seven pages of items in AMDs for which there has never been an issue.

(*b*) The percentage scale of holdings of evaporator pumps has gradually been increased as a result of experiencing high replacement rates. But the same high percentage scale applied to a recent class is too great as the pumps in this new class are much more reliable than their predecessors.

The cost of over-provisioning and the loss of value, i.e., loss of availability caused by under-provisioning, is difficult to quantify. But if I were asked for an estimate it would be in £ millions. Therefore a major task of the Section in the future will be to buy only that which we essentially need to achieve the greatest cost effectiveness.

Cost effectiveness is the ratio of value to cost.

EFFECTIVE NAVAL VALUE (ENV)

(FROM JOURNAL OF NAVAL ENGINEERING—DECEMBER 1968)

VALUE LOST BY SHIPS THAT HAVE AN UNPLANNED LOSS OF AVAILABILITY STATE A TO C

EXAMPLES :—

H.M.S. VALIANT	£ 89,600 / DAY
H.M.S. OBERON	£ 12,450 / DAY
H.M.S. JAGUAR	£ 18,000/ DAY

STATE A – NORMAL NOTICE

STATE B – 7 DAYS NOTICE

STATE C – MORE THAN 7 DAYS NOTICE

FIG. 3

Unfortunately, it would seem that few in MOD(N) know, or give much thought to the difference between cost and value. Cost is what the taxpayer has paid or will be paying *in toto*.

Value in the case of Depot Spares (FIG. 2), or any spare for that matter, can be defined as:

(*a*) Loss of availability, performance etc. saved by having a spare where you want it when you want it, and

(*b*) Additional costs (e.g., man-hours maintenance, *ad-hoc* repairs, cannibalization, etc.) saved by having a spare where you want it when you want it.

OPTIMISING STOCK OUT RATE

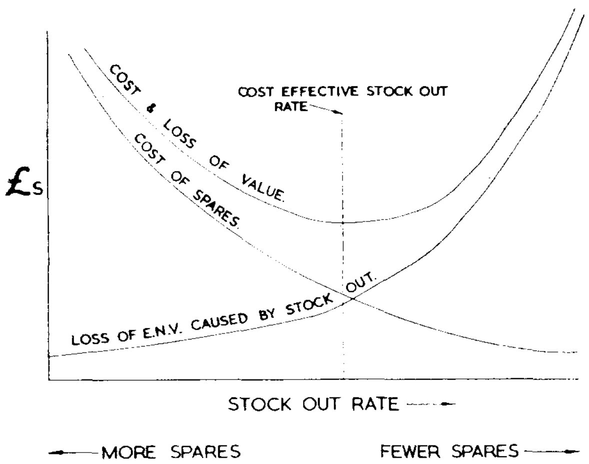

FIG. 4

REPLACEMENT LEVELS

A	EQUIPMENT	I.E. WHOLE EQUIPMENT REPLACED.
B	ASSEMBLY	E.G. DRIVER OR DRIVEN ENDS REPLACED.
C	SUB-ASSEMBLY	E.G. GEARBOX, GOVERNOR REPLACED.
D	COMPONENT	I.E. PIECE PART REPLACEMENT.

A, B, & C ARE DEPOT SPARES.
C & D ARE SPDC SPARES.

FIG. 5

Commander Collis in his paper published in Vol. 18, No. 1 of the *Journal of Naval Engineering* in December 1968, quantified the loss of value experienced in various ships should they lose a day of planned availability. Typical figures calculated by him are given in FIG. 3. His units of value he calls ENVs (Effective Naval Value) where the values in state A, B and C are in the ratio 10 : 3 : 1. In other words, he estimated that a ship in state A is worth ten times as much as in state C.

From these figures one can easily see how to work out the value of having a Depot Spare propeller for these ships. Provided the value is greater than the cost it is worth buying. For a class of ship it is slightly more difficult to work out the cost effective number of spare propellers that the Navy should own But FIG. 4 illustrates in the simplest way how to arrive at the cost effective holding. By adding a curve of the cost of spares to another of the value loss we shall produce a curve that has a minimum which must be the cost effective point.

To determine this cost effective number of spares the Section needs to know:

(*a*) The military essentiality of the equipment, i.e., the percentage of the ships ENV that will be lost should that equipment be unserviceable.

(*b*) A prediction of the failure rate necessitating replacement.

(*c*) The planned replacement rate, i.e., the R by R rate.

Only the R by R rate is known to us at present.

You may believe that I have been discussing complete equipments—feed pumps to potato peelers, but we stock assemblies and sub-assemblies as well as complete equipments and the same arguments apply to them. But we have an additional problem in that we have to decide exactly what to buy. All of us are guilty of talking about an equipment as being R by R, which many interpret as meaning that at refits the equipment will be removed and another fitted in lieu. But do we define exactly what can be exchanged? There are four replacement levels (see FIG. 5):

REPAIR CYCLE EFFECT ON CAPITAL COSTS

1	CAPITAL COST OF NEW UNIT	£ 19.000				
2	AVERAGE OVERHAUL COST	£ 10.000				
3	NUMBER IN SERVICE	23				
4	REFIT BY REPLACEMENT INTERVAL	2 YEARS				
5	FAILURE REPLACEMENT RATE	SAY 2 PER YEAR				
6	ANNUAL ISSUES FOR R BY R	$\frac{23}{2} \approx 12$				
7	TOTAL ANNUAL ISSUES	12 + 2 = 14				
8	PLANNED REPAIR CYCLE TIME MONTHS		6	7	8	9
9	Nº OF SPARE UNITS NEEDED $= \frac{\text{TOTAL ANNUAL ISSUE}}{12} \times$ REPAIR CYCLE TIME		7	9	10	11
10	CAPITAL COSTS OF SPARE UNITS £,000		133	171	190	209

ONE MONTH REPAIR CYCLE TIME IS WORTH £ 19,000

FIG. 6

Levels A and B are usual at refits and all levels are employed at times other than refits. Before accepting an equipment for naval service, in fact before the design is finalized, a decision must be made on replacement levels. For the interfaces between equipment and ship, and between the equipments and its replaceable assemblies and sub-assemblies, must be toleranced to ensure interchangeability. Change units must be specified and must have their own GA drawing so that we can buy what is needed and so that what is bought will fit. We are currently tackling this task with the MCMV and we are hopeful that the Type 42 and later ships will similarly be treated.

Now let us consider the repair cycle and its effect upon the number of spares to be owned. As an illustration, an equipment has been chosen that has a very high military essentiality. The ENV loss would be approximately £6,000 a day. FIG. 6 shows that for increasing planned repair cycle times we need to own an increasing number of spares, one month of repair time being approximately equivalent to one extra pump. Since the inception of R by R we have attempted to plan on a basis of a six-month repair time, allowing one month transit time between Dockyard and Overhauler. In fact the achieved repair time has always exceeded the planned figure and a major contributor to this increase has been delays in transit from Dockyards. These delays can be measured only in terms of loss of value, i.e., the extra cost or loss of ENV. A sobering thought.

As regards the actual time to repair we could look at the cost effectiveness of capital investment to speed repair or, in the case of contractors, financial incentive. In the example shown in FIG. 6, 14 pumps will be overhauled per year. Assuming a pump life of 15 years it will be cost effective to offer a financial bonus of £90 per equipment overhauled to achieve a reduction of one month in the repair time. As regards capital investment, in the example, it would be cost effective to spend £19,000 on such things as buffer stocks of long lead items, repair facilities, etc., if by so doing the planned repair time could be reduced by one month. It must be emphasized that these measures should be considered at the planning stage before Depot Spares are ordered, as the saving is to be achieved by reducing the number of spares to be owned.

I might, quite justifiably, be accused of using averages in the worked example in FIG. 6 and of neglecting to take account of the laws of probability associated with failures. This was done deliberately in order to make the point clear. Those who are familiar with the expression $e^{-\lambda t}$ must bear with me so that those who are willing to know more about random failure and its effect on Depot Spares can have their appetite satisfied. The expression in FIG. 7 shows the probability of zero, one, two, three or four failures occurring in time t, where $\lambda = \frac{1}{\text{MTBF}}$. By substituting the repair time for t we will thus obtain the probability of a failure occurring before we have had time to repair the defective equipment removed at the previous failure. Supposing it is acceptable to Management that the probability of having a serviceable spare is not less than

FAILURE PROBABILITY

$$e^{-\lambda t} + \lambda t e^{-\lambda t} + \frac{(\lambda t)^2 e^{-\lambda t}}{2!} + \frac{(\lambda t)^3 e^{-\lambda t}}{3!} + \frac{(\lambda t)^4 e^{-\lambda t}}{4!} + \dots\dots\dots$$

BY SUBSTITUTING TIME TO REPAIR (M.T.T.R.) FOR MISSION TIME t, THE NUMBER OF SPARES NEEDED TO ENSURE AN ACCEPTABLE PROBABILITY OF ONE SPARE HAVING COMPLETED REPAIR WHEN A REPLACEMENT IS REQUIRED, CAN BE DETERMINED.

FIG. 7

TWL 20M FEED PUMPS

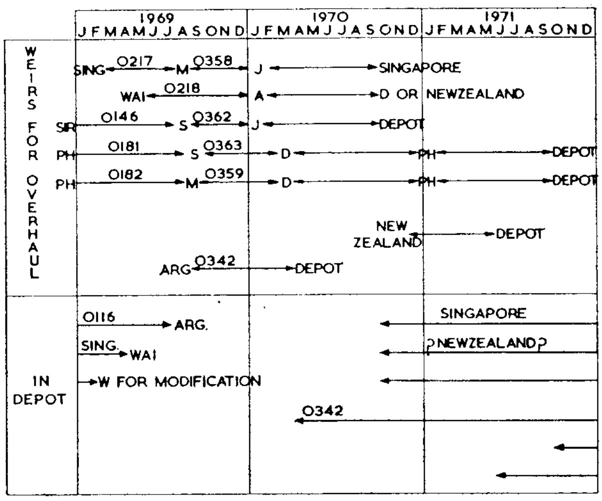

FIG. 8

90 per cent, then if $e^{-\lambda t}$ is equal to or greater than 0·9, one spare is sufficient. If it is less than 0·9, then at least two spares are essential. Similarly if the sum of the first and second terms in the expression is equal to or greater than 0·9, two spares will be sufficient to meet the randon failures. Everything has a random failure rate and one cannot therefore realistically provision with spares so that one always has a spare in stock when one is needed.

From the foregoing you will probably conclude that the terms of reference of my Section should be:

'To provide cost effective Depot Spare support for the Fleet within specified acceptable levels of stock-out'.

We come now to the long term planning of the Depot Spares support—the cycle of issue, return, repair and reallocation to store or ship. As an example of what we are doing, FIG. 8 shows the forecast for TWL 20 feed pumps which looks $2\frac{1}{2}$ years ahead. It is compiled from ships records and the R by R periodicities laid down in the Maintenance Schedules. There are many such forecasts. They change often. The task of keeping them up to date is a big one but very necessary if the repair lines are to plan their work to meet the requirements of the Fleet. We are currently investigating using a computer to print out each month, equipment by equipment, the Refit by Replacement needs $2\frac{1}{2}$ years ahead.

DG Ships decides the repair policy in conjunction with DGD and M; it is then the Section's task to decide the Repair procedure in conjunction with DGD and M and DNSP. To do this the Author chairs a Joint Working Party to decide and adopt the best repair procedure whether it be Dockyard, Dockyard line Overhaul or Contract Repair. Clearly the best repair procedure is the most cost effective one. We look forward to the day when we shall have Dockyard repair costs for comparison with the costs of repair elsewhere. The stumbling block that presently prevents us from determining the most cost effective course of action is the antiquated financial system geared to producing figures for Parliament, very few of which are of any assistance in making material management decisions.

The Spare Gear Group is currently referencing all equipments, assemblies and sub-assemblies (as well as component parts) for new design equipments to be installed in the Type 42 and subsequent ships. These will have Adrefnos under class codes 074, 073, 072 for electrical and 084, 083, 082 for Hull and Engineering respectively. There will, of course, be a 15-year transitional period when Depot Spares will be only partially referenced. To bridge this gap the Section has embarked upon a referencing scheme for the Depot Spares only for ships now in service. All Mechanical and Hull equipments, assemblies and sub-assemblies stocked as Depot Spares will be referenced under class code 085. To date all GP and GMD Mechanical equipments have been so referenced and lists have been promulgated to ships and authorities concerned. Depot Spares for the *Whitby*, *Rothesay* and *Leander* Classes will be referenced in the near future.

In conclusion it should be placed on record that the centralization of responsibility for Depot Spares in the hands of one Section, albeit not yet fully realized, has resulted in considerable benefits to the Fleet and has probably saved a bit of money into the bargain. It has meant a lot of hard work not only in my Section but also by our good allies in DNSP, DGD and M and D of S. When we transfer to DGST in May next year we look forward to the same high level of co-operation that we have enjoyed here in the Ship Department.