DESIGNING FOR A MAINTENANCE POLICY

A NAVAL CONSTRUCTOR WONDERS WHAT HE CAN DO ABOUT IT IN FUTURE SHIPS

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Ten years ago this sort of question meant very little to most of us. Now we have to defend ourselves against an unending stream of them. Do we have to have long refits? What criteria decide habitability standards? What are the costs and benefits of upkeep by exchange? Each is a quagmire of other questions. All are much easier to ask than to answer.

Upkeep is itself a quagmire: we sink more than half the Navy Vote into it, if one counts all the labour (naval and civilian), plant, facilities, materials and spare parts. Upkeep gets relatively more expensive every year, as it is such a labour-intensive business. To control it better, we need better accounts of where the money and effort go. Of course everything has always been accounted for in a way; Parliament and their administrators have insisted on that. But it is quite another matter to get accounts which are useful to engineers in reducing the upkeep of specific systems and equipments. Accounts good enough for Parliament are far too crude to be much good in controlling the reality of upkeep, or in providing a basis for design for upkeep.

The need for better information as well as accounts is generally accepted. Developments are in hand, but there is also a widespread feeling that our ships are still not being designed with upkeep sufficiently in mind. May one who, rightly or wrongly, is in the ship design business (and is therefore fair game for anyone serving at the sharp end) try to describe some of the catches on the road to upkeep virtue?

Admiral Nixon has already written about the main facts of the matter—the necessity of properly organized information, deciding the broad method of repair of every equipment, finding the best balance between availability and cost, increasing the efficiency of maintenance work. He defined the aim of maintenance as:

> 'to provide the Command with the designed performance and availability of ships and their equipments.'

His article in the *Journal of Naval Engineering*, Vol. 20, No. 2, (June 1972) lays down a very reasonable gospel. This is much needed, but it gives, as he would surely agree, only the overall principles by which we have somehow to find our way in the day-to-day slog of what in practice seems to be a rather messy activity.

The designer has a particularly long path to tread in learning how to apply the upkeep gospel. He has to learn how to design a ship (or just a ship system) with a specified economic life, with correctly predicted upkeep effort, skills, and time profile of application, spares consumption and the rest, all optimized for usage, cost effectiveness and an abundance of other things.

Having been convinced of the need to attempt this, our designer pilgrim sets out by swotting up reliability (and that means a not-so-short course on probability). He finds that he has strayed away from his professional terra firma of deterministic physical causes and effects: he has wandered through the Looking-glass into a land of Uncertainty, Confidence Levels, and, if he persists, confusing Multi-valued Decisions and agonizing Minimax Regrets. Not even Constructors thought they joined for that! Finally, having battled with these intellectual monsters, our Pilgrim finds himself almost totally bereft of data. Bloody but unbowed, he sets up an Order of Upkeep Brothers to organize and cultivate a base of upkeep information, but of course this is a long task. Hoping to make some progress in the meantime, he turns to the aim of maintenance and enquires about the origin of 'the designed performance and availability', only to find them to have been handed down from Whitehall, where the gods live, with little regard for Multi-valued Decisions or any other Looking-glass fauna. Plainly there is more in this gospel than meets the eye!

However, the journey has enabled our designer to recognize that the main snags in designing for upkeep are:

(*a*) Lack of data on:
- (*i*) Failure rates of random and of wear-out failures.
- (*ii*) Corrective effort and preventive effort.
- (*iii*) Other costs of upkeep (facilities, spares and support services).
- (*iv*) Downtime (or non-availability).

(*b*) Lack of means of arriving at the 'best' balance, within available resources, of:
- (*i*) Usage, its time pattern and performance or mission profile.
- (*ii*) Availability.
- (*iii*) Reliability.
- (*iv*) Method of support.

Admiral Nixon had described the steps being taken to help with the lack of data, the Ship Upkeep Information System (SUIS) and the technical investigations of the Ship Maintenance Authority. Opinion about these developments varies from near total disbelief in the value of either to a total faith that in time they will provide all the answers. Would that the faith were so justified! However, given another five years and enough push from ships' staff in the form of good, sustained reporting, then both SUIS and the SMA will be producing upkeep data that every responsible designer will think essential for his work. We shall then be on our way towards designing for upkeep.

What can be done for the ships whose conceptual designs may be starting now? More ship capability, reliability, availability, and usage per £ spent is demanded to keep the Navy going as an even greater proportion of the Defence Vote is gobbled up in pay. The need to consider upkeep in ensuring value for money is indeed pressing. However, it is a fact that, when contemplating a ship to be bought in say ten years' time, the amalgam of naval officers, administrators, designers, and politicians, making up the MOD and Treasury decision taking levels, finds it very hard to see far beyond the initial purchase price. These payments are large, discrete, and easily controlled by piecemeal surgery. So the budgets are balanced.

There are some signs of increasing concern for the life cycle costs of ships (which amount to about four times the initial purchase price), but it has to be faced that the level of that concern will have to rise a long way before the allocation of resources is decided by considering them, and not just first costs. It is difficult to see how this concern can rise far until the costs of upkeep (and of operation, although these are relatively minor) of a proposed ship can be estimated with the same accuracy and felt validity as is now attached to the purchase price. So, once again, we are led back to the need for data on upkeep costs and the need for all the dull reporting from ships and dockyards of upkeep activities, and the need to support a general conviction that it matters because upkeep is big money and must be everyone's business to take a hand in its control. Until that happens, life cycle costs will be seen as rather conjectural omelettes of figures—sloppy stuff compared with the hard tack of initial costs.

This problem is not, of course, peculiar to warships: no motor car designed for upkeep would ever be commercially viable and, in consequence, the World wastes millions of pounds each year. Lorry and aircraft operators take more account of upkeep but, like the Royal Navy, they too have difficulties in getting upkeep information in the right form.

However, upkeep considerations are taking a large part in the choice and design of quite a number of ship equipments. Several recent articles in this *Journal* explain how much has been done in this direction with the large equipments like main engines, gearboxes, and Diesel engines, and with important types of components like seals and bearings. This is making it possible to design ship systems with both reliability and upkeep in mind (for they are inseparable) in a way quite impossible only a few years ago.

Early design studies for possible future ships, now on the drawing-board, are having the main features of their principal systems determined by recently developed methods by which the reliability of alternatives can be compared. It would be too much to say that it is yet possible to calculate the absolute magnitude of the reliability of systems at such early stages of design. However, to be able to compare alternatives is a great step forward, and the critical nature of the process sharpens up both the design and the requirements it is intended to meet, for at this conceptual stage both are being developed.

The miscellany of less glamorous workaday systems is more difficult to handle. In aggregate, these are about as expensive as the whole propulsion system in many ships, and they consume a great deal of upkeep effort. Specifications have been 'improved', usually at considerable increase in both complexity and initial cost, generally to reduce the upkeep. Rarely has any overall advantage been proved. The necessary data do not exist. That is another of the things that SUIS is all about. In the meantime, however, the financial squeeze on defence matériel is forcing a painful awareness that ship systems now being installed have become cumulatively so expensive (by a long process of piecemeal improvement) that they are difficult to justify. Pumping, flooding, and draining systems, for instance, now cost something not far short of 10 per cent of that for the whole ship!

Apart from rises in labour costs, costs have increased through rising standards in material quality, in consistency of that quality, in the performance of systems, in duplication, and in measures and devices for safety of operation, for surveillance and for control. Many such changes are aimed at reducing complements and upkeep; on that score, they have a reasonable chance of being worthwhile. Other changes, however, owe their origin to somewhat loose, if well meaning, attempts to enable systems to survive combinations of misfortunes, the probability of whose combined occurrence is often remote—too remote to justify the cost, and in many cases result in reduced reliability due to the added complexity. We have reached the point where to design against every eventuality that our communal experience can remember or logic conceive has become self-defeating. Our cleverness has often outrun both our wisdom and our pockets.

A much more discriminating approach is necessary in future and the next few years are going to see a marked change in the Navy's design style. The trend towards complication will be reversed. Systems must be simplified down to what is necessary to meet acceptable levels of reliability (which will become vital system parameters) during stated mission times. Mission times will tend to shorten to enable systems to be simplified under these design conditions in order to reduce costs (initial and upkeep). A relatively rare type of failure, even though engraved on the memory of many officers, must not be allowed to lead to additional stand-bys or cross-connections unless the case stands up to a statistical examination. Everything in a ship from men to pipes and valves can only be justified if it pays its rent, and ships' rents are very high—a sleeping berth probably costs about £5 per day all told!

'What you haven't got gives you no trouble'. This simplification, properly chosen, reduces upkeep and increases reliability. The reliability assessments needed to make the proper choice depend on data for mean times to repair (MTTR) as well as mean times between failures (MTBF), and the rate at which it will be possible to extend what is being done now with the principal systems will depend on how the necessary data in SUIS build up.

Driven by the massive transfer of Defence budgets from material to pay, and the consequent need to reduce complements and upkeep, future ships must be designed with the greatest possible (but discriminating) simplicity, with markedly reduced complements, and for a specified upkeep effort which will have to be almost entirely ashore. Is that an upkeep policy for the designer? How far it will be possible to carry it out, time will show. But we will try.