# IN PURSUIT OF A MARINE ENGINEERING POLICY THROUGH SYSTEMS ANALYSIS

BY

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A recent column in *The Times* reviewed an article entitled 'Decline and Fall in the Boardroom', which described the 50-year old who 'bumbles and fluffs his decisions'. Finding an analogy with the change of life in women, 'it could well be' said the writer, 'that this loss of decision-making ability is part of a general decline in potency, using the word in its broadest sense. A partial solution could be hormone implants'.

Whether it was the vision of D.M.E. and his directing staff lining up to receive hormone implants or because 'the 50-year old' tag stuck in their throats or merely because, for once, thanks to the Naval Secretary, there seemed to be a period of ten months before the next officer on the directing staff was to be relieved, a decision was taken to subject the whole field of D.M.E.'s work to a long, hard, methodical and very detailed examination.

## PART I
### DEFINING THE PROBLEM

A preliminary study suggested that this examination should be divided into two major fields as follows:-

(*a*) To establish precisely the resources available to D.M.E. and to balance these against the task

(*b*) To increase the resources by all practical means and to cut the task to ensure it was well within whatever resources could be made available.

Unlike the other two directorates where to some extent the task can be measured in terms of drawings to be produced or approved, D.M.E.'s task of monitoring designs produced by industry can be done in depth, in which case the subsequent designs and equipments are more likely to be satisfactory or done only superficially, in which case future machinery and equipment may well be unreliable. If an imbalance occurs in the staffing between D.M.E.'s ship installation Sections, who inevitably aim to proceed at a speed dictated by the design programme, and D.M.E.'s specialist Sections, whose speed of advance should be dictated by the load deriving from the need successfully and effectively to monitor all designs of machinery involved in the programme, something must give. Either the D.M.E. element of the design programme, as

instanced by the progress of the ship installation Sections, will fall behind because of lack of information as to future equipments from the specialist Sections or equipment design scrutiny by the specialist Sections will become inadequate and highly superficial. If, in addition, the running ship Sections find that design failures in the running fleet also require attention by the specialist Sections then the specialists are likely to become more and more preoccupied and the imbalance in terms of the effort which should be devoted to the fleet being designed—and which can actually be so devoted—becomes catastrophic. The answer—more staff—is too easy. In a world where almost everyone is working hard or indeed is grossly overworked, cries for more staff are commonplace and usually unheeded. Something more factual was required.

**The Role of Systems Analysis**

Systems Analysis has nothing to do with systems engineering; it has a much broader application than operational research. It is a reasoned approach to problems of decision; a systematic attempt to provide those who have to make the decisions with a full, accurate, and meaningful summary of information relevant to clearly defined issues and alternatives. Always there is a necessity for choice. Systems analysis tries to define those areas where choice can be founded on fact and those other areas where facts cannot be so clearly ascertained and where judgment is necessary. To apply these techniques to D.M.E. meant more work for already overworked professional officers and a small Section had to be created as a Systems Analysis office, as a central clearing house for the studies and ideas which flowed upwards, once the directive setting the task had gone out.

**What does D.M.E. do?**

Ask this question of any of the denizens of Foxhill and you will get a different answer, varying probably from the polite to the frankly obscene. A precise and objective analysis was required and so a computer programme was written and coded up which could give a broad or a detailed answer, whichever was appropriate.

Five main 'activities' were defined (actually in great detail) or in broad terms as follows:-

1. Fundamental work
2. Equipment design
3. Installation design
4. Running Fleet work
5. Administration—Standardization—Drawing procedures—Training, etc.

Further codes were devised to cover effectively every ship or class in the Navy and all types of equipment or machinery with which D.M.E. has to deal. Lastly, cards were provided which, with the minimum of effort, would enable every professional and drawing office grade to record how he spent his time. Considerable trouble was taken to 'sell' the idea that this was no inquisition and this paid off because very few, if any, took advantage of the offer to render returns anonymously. Most were concerned, despite the trouble involved, only to ensure that their returns were scrupulously and accurately filled in.

Within three months a repeatable pattern had emerged. D.M.E. knew almost down to the nearest half man-hour how his resources were deployed.

### Lack of Resources

The worst fears were confirmed and the returns revealed that the resources available for the monitoring in depth of new designs were inadequate. From this a factual and balanced case for reinforcement was prepared, forwarded and quite quickly approved. Steps were taken to recruit more professionals, more senior posts for drawing office staff were agreed after an inspection by Civil Establishments Branch and the stage of the programme referred to above, which came to be known as D.M.E.'s Salvage Operation, was well launched. It was time to examine the task.

## PART II

### DEFINING THE AIM AND THE DIFFICULTIES IN THE WAY OF ACHIEVING IT

### D.M.E.'s Task

For the purposes of the Work Analysis already referred to, D.M.E.'s task had been divided into five groupings. For this exercise it was divided into three categories:

1. The future fleet
2. The building and designing fleet
3. The running fleet.

The composition of the last two are fairly obvious. The initial category consisted at first of all warships over 1,000 tons in the 'Long Term Costings'.

There is no magic in Systems Analysis and no short cuts. It is a systematic attempt to define and, where possible, to solve problems or to contrive viable alternative solutions.

First the scenario had to be set.

### The Aim

Necessarily this was a crucial debate. D.M.E. wanted efficiency: he wanted to obtain the greatest possible availability from a given budget, both because availability itself was of such transcendent importance, and because the more efficiently D.M.E. used his budget the more resources were available for other Fleet requirements. D.M.E.'s problem was: how could he use the resources allocated to him to buy better mobility at sea in the Fleet we have; in the Fleet on the drawing board and in the Fleet in the conceptual stage?

The aim D.M.E. felt, was inescapable, namely:

'To achieve greater availability, in all three areas; and this gave rise to a more precise D.M.E. target as follows:

'Less maintenance and repair'

or

'Quicker maintenance and repair'

or

'both'.

### The Parameters

The parameters which we assume to be inevitable and within which this target would have to be achieved were then examined and the following established:

(*a*) *Money*. There will almost certainly be much less—not only because the overall Defence Vote is reducing but because an increasing proportion may have to be spent on commitments already entered into which cannot quickly be eliminated;

(*b*) *H.Q. Manpower.* At the best this could increase only marginally—more probably it will eventually reduce;

(*c*) *Uniformed Technical Manpower Afloat.* Numbers needed may have to be reduced; not only because the men may not be available but also because it is desirable that the sea/shore ratio must be improved.

D.M.E. has long worried over the economic use of fuel and indeed endurance is an essential military target. However, during a 20-year life the uniformed manpower cost of a ship is ten times that of the fuel. A reduction in manpower is not only a likely parameter but also a justifiable aim.

(*d*) *Dockyard Productivity.* Various measures already taken, or in hand, are likely to cause an increase in dockyard productivity per man. But the rundown in the labour force, the increasing work content of old ships and the running fleet under the predicted operational tempo and the impact of the nuclear programme, will presumably make it essential for D.M.E. to plan for a net *reduction* in overall dockyard effort as far as D.M.E. equipment is concerned.

**Lessons of History**

The next study to be commissioned was one which looked at any possible pitfalls into which our predecessors had fallen.

After all, the Y.100 and the gas turbine boost machinery were both brilliant in conception and in execution.

The study concluded:

(*a*) There had not been an early enough advance in engine-room rating training. (Even though in those halycon days E.-in-C. was largely master of his own training machine);

(*b*) The case for administrative and logistic support through refit and repair by replacement had not been accepted and implemented on an adequate Navy-wide basis;

(*c*) The dockyards had never been informed early enough or trained soon enough in the proper techniques and skills which should go hand in hand with the advances which were occurring in machinery.

All three in the political climate of the 'fifties were probably inevitable. The wonder was that, with the resources at his disposal, the E.-in-C. came so far.

**Competitive Tendering**

Another study highlighted the dangers into which D.M.E. is standing if the philosophy of competitive tendering (over which D.M.E. has little direct control) is applied too rigidly. There must come a moment when profits have finally been squeezed out and tenders are won on skimping, which is never easy to identify, or which can only be identified by massive professional and sub-professional scrutiny of industry's designs, for which as has already been mentioned, the means simply do not and are never likely to exist.

**Conclusion**

The aim was clear; the hurdles were massive and a bit daunting.

## PART III

### OVER TO THE OFFENSIVE

One of the many merits of Systems Analysis if properly practised is that it enables problems to be looked at objectively in all their starkness. From the

multiplicity of studies which were undertaken in D.M.E. applying the criteria described in Part II to the running, building and designing and future fleet, certain common features emerged which seemed inescapable.

The expense of immobility is high by any standard. Ships are far too expensive and scarce to be used as floating laboratories and test vehicles for newly developed machinery. The vast sums of money poured into the development of electronic devices and weapon systems will be utterly wasted if the ship is incapable of movement or manœuvre. If the Admiralty Board is to be able fully to prove to the Secretary of State that a warship is 'Cost Effective' then machinery must be reliable and trials must be carried out ashore and must be substantially complete before production models are installed in a ship. Once installed then machinery must be made available, without massive maintenance effort, for even more of the ship's life than is achieved today. Intervals of unserviceability must be restricted to those needed to bring the weapon systems to an acceptable degree of modernity and these intervals must include the time necessary to bring the machinery to a state where it will continue to give trouble-free performance with a minimum of uniformed personnel.

In detail as far as H.Q. was concerned this meant:-

**The Running Fleet**

There must be increasingly ruthless rationing of D.M.E. H.Q. manpower resources made available to the running fleet but at the same time the service now given to the hard pressed engine-room crews must not diminish; if possible it must increase.

To this end certain preliminary steps have been taken:

*Project MOBUS* (MObility is our BUSiness) has been established. A small staff headed by a senior commander direct from sea, with no clerical assistance whatever (and therefore a minimum of paper work) has been set up under the authority of a Deputy Director with complete access to all the appropriate echelons in H.Q., the dockyards, the H.F. Staff and F.O.S.T. His task is to eliminate or mitigate the effects of design and other faults designated 'Ship Stoppers'.

*A Modification and Identification Procedure* for machinery and equipment, the work of many people for nearly three years, has happily gelled and has been introduced. Much A. and A. work and therefore H.Q. effort and time is expected to be saved thereby.

*Depot Spare Equipments.* Increased provisioning of depot spare equipments well above anything previously regarded as essential has been arranged so that pressure on the dockyards, which has sometimes meant their inability to 'turn round' equipments sufficiently rapidly, will be diminished and serviceable equipments should be more readily available.

*Liaison with D.N.E.E. and D.N.C.* Many of the problems are common to two or even all three of the directorates. Even closer ties between the directorates are being forged. MOBUS, though a D.M.E. officer, has direct access to all three besides the Directorate of Naval Ship Production, and Directorate of Naval Contracts and to Directorate of Stores; as also of course has the Assistant Director Spare Gear.

Monthly 'Ship Availability' Meetings, for long held in London, are now held monthly by the Vice-Controller in Bath and at a higher level of attendance than before. Though this action by the Board was of course taken entirely separately to the measures here being described it has helped to invest them with a welcome sense of urgency.

*Summary.* The offensives to maximize D.M.E. Running Fleet support within the H.Q. resources available have thus been launched. A few other measures are in hand and these will take some months to develop. There is one more thing to be said.

The Fleet and Fleet Staffs must bear in mind the price that others now or in the future have to pay when one ships 'hogs' the services of one of the all too few professional officers at H.Q. The effect not long ago of the virtual 'shanghaiing' by a Carrier of one officer for a considerable period meant that all the problems in the running, building and future fleet to do with the particular equipment concerned, besides those in the dozen or so other types of vital equipment for which he was responsible, were wholly neglected as far as professional effort was concerned.

Help is always gladly given. It should not be abused.

**The Designing and Building Fleet**

The main offensives here should be in three areas:-

(*a*) Administrative and executive procedures involving
  (i) The establishment of check lists for manufacturers
  (ii) Certification by manufacturers that designs and drawings have incorporated all the requirements of check lists and specifications
  (iii) Better training of draughtsmen (Feilden Report)
  (iv) New and more rigid acceptance procedures for machinery on the lines of those already in force for nuclear submarines
  (v) A whole host of measures directed at quality of manufacture and installation.

(*b*) Full information to the dockyards at the earliest possible stage of what will be required of them for the servicing of the machinery now 'in the pipeline', including the needs for dockyard services.

(*c*) A new look at competitive tendering; of how a firm winning a tender can be bound more tightly to the after care of their machinery; of how the required life of equipment can be better assessed and specified.

In all these fields there is still much to be done and any effort that can be found or procured in the next six months will be deployed on these offensives.

**The Future Fleet**

In this direction the necessary Papers are now being prepared on the lines described hereafter.

The application of Systems Analysis to the future fleet has involved a long hard look at all the ships and larger vessels in the forward costings in terms of their probable needs for

(*a*) Speed and endurance
(*b*) Power requirements
(*c*) Water requirements
(*d*) Air, oxygen, and chilled water requirements

as well as in terms of the four major parameters of

(*i*) Less money
(*ii*) No more H.Q. manpower
(*iii*) Less uniformed technical manpower
(*iv*) Less available dockyard effort

which we assumed earlier.

From this, for the Fleet in the conceptual stage, there has been derived the 'Systematic Machinery Selection Concept'.

The word 'systematic' in the Oxford Dictionary is defined as 'methodical'; 'according to a plan'; 'not casual or sporadic'; and this is what it is hoped to achieve. Something less than complete standardization, but a concept which is patently established according to a well-ordered plan.

In practical terms an attempt has been made to define a minimal number and variety of gas turbines, Diesels and steam machinery sets (nuclear or oil powered) which, singly or together, will satisfy most of the needs postulated by the Naval Staff; furthermore, the plan has been tested in the field of auxiliary and ships service machinery provision.

There is of course nothing new in the idea of a standard, or systematic, machinery selection concept. Many attempts have been made to introduce it earlier, but in a world of tailored steam plants, they inevitably failed. It is, in fact, the adoption of Diesels and gas turbines for propulsion purposes which makes such a concept a practical proposition now. These self-contained power plants are capable of comprehensive development ashore; backed by adequate development effort which can be afforded in relation to the large potential market (rarely, if ever, applicable to purely naval machinery); and from which the auxiliary requirements can be considered separately. There is a real prospect of covering a wide range of propulsion powers with a few self-contained prime movers used singly or in combination. For main propulsion, a systematic machinery concept by equipment can be achieved—or so it is believed.

With the use of internal combustion engines for propulsion the auxiliary requirements can be considered separately. That is, electricity in ever-increasing quantities; the ability to make drinking water and possibly small quantities of high purity water; compressed air at a great variety of pressures and conditions of cleanliness; air conditioning and refrigeration.

Not enough is yet known as to how to provide these services most economically, efficiently and reliably. Steam has always been a useful medium for distilling plants, for water heating, galleys, arcticization etc. and saves electrical generating capacity. Should Diesel or gas turbine alternators be used with waste heat or jacket heat boilers, or with separately fired auxiliary boilers? Should flash evaporators be used with two or three or four stages, or vapour compression machines? Should remote and automatic control systems be pneumatic or electronic? There is an endless list of alternative ideas. If each is pursued for each fresh requirement then the present logistic jungle will grow even more impenetrable. The possibilities must each be analysed, costed in terms of resources and operational limitations and studied with great care so that only a limited number of options is provided for all these services and once provided adhered to for a defined period. This then is the nub of the matter. Equipments large or small should be reasonably standardized not by Class of Ship as heretofore but instead by equipment for measurable periods of time; the only criterion for any one Class of Ship being that the operational characteristics are not significantly altered by any advance or change in equipment.

Certain bogies have always appeared when such ideas as the Systematic Machinery Selection Concept have been discussed in the past. These are stagnation, monopoly, and stifling of design initiative. It is the contention that none of these bogies have any real substance. The original engines chosen for the Standard Range Diesels in 1950 have now been replaced by those selected in 1963. These engines are the most up-to-date in the U.K. It is of interest that they come from the same stables as the previous ones, but all possible designs were considered in a field where there is extensive and fierce competition. Provided machines are bought which are designed for, and actually being sold in reasonable numbers, in a commercial market, then there is surely no fear of

stagnation or monopoly. On the other side of the coin, almost all equipment for naval steam installations and many independent auxiliaries have nearly always been designed specially for the Navy. Numbers off are very few and the profit to the firm is very small. Stagnation, can therefore, easily occur and can only be prevented by constant pressure from the Navy, whether there are one or many firms who are prepared to undertake design. Monopoly is irrelevant in this field of 'specials'. The Navy will be in a much better position to achieve good designs if the number of these 'specials' is strictly limited and there is time to monitor and develop thoroughly. Nuclear surface propulsion is an obvious case in point.

**Overhaul by Replacement**

The second part of the 'future look' has shown up, dramatically, the need to revive the policy of Refit by Replacement in full degree.

The need to keep the Fleet more continuously at sea inevitably brings more wear and tear and the only way to replace worn out equipment quickly is by the use of what is now coming to be called 'Overhaul by Replacement'.

For some years something like this has been implicit in D.M.E.'s design policy but, for a variety of reasons serious attempts to implement it have been made only in the Types 12 and 14 frigates; and even in these Classes it has taken ten years to reach the present not yet wholly satisfactory state.

Overhaul by Replacement as an abiding policy comprehends not only installation and component design but has vast implications in the provisioning and training field. It can never be properly implemented without some radical changes in the dockyard organization; it will certainly cost money and may cost some slight diminution in the weapon load. The great merits claimed for it are that it will increase availability and may reduce the need for skilled uniformed manpower afloat.

*Installation Design*

The whole concept of Overhaul by Replacement depends on the item of machinery that is to be removed and replaced as a unit whenever anything more serious than the trivial goes wrong, being so positioned that removal is fairly easy. If a machine is very difficult to remove, or if removal involves a large amount of consequential stripping, or if the removal path is restricted or tortuous, the time taken for the job is so increased that it may actually be quicker to refit it on the spot.

It is therefore necessary to provide:

(*a*) Space round the various items of machinery to enable them to be disconnected from their seatings and from the systems of which they form part. This is normally sufficiently catered for in modern designs by the space provided for routine maintenance, and

(*b*) Easy disconnection and easy slinging; fixed gantries and rails are convenient, but not, in general, essential, except in those locations where ordinary slinging gear cannot be used. The design of the machine itself must also lend itself to convenience of slinging.

(*c*) A reasonably uncongested route to the point from which the machine is removed from the compartment. Ideally, no consequential stripping should be necessary, but this is often not practicable in a warship. On the other hand it is essential that really vital machinery should not be immobilized, just because something else is being removed.

(*d*) A removal path from the machinery spaces to the upper deck. The ideal is a trunk, large enough to take the largest item of machinery that has to be removed as a single unit and which is unobstructed except by easily portable equipment, such as ladders. If a trunk cannot be provided, in line hatches of the requisite size will suffice, provided that the ships domestic arrangements are not reduced to chaos every time the route is used. The basic requirements is that a crane should be able to plumb right down into the machinery spaces.

*Basic Requirements for Provisioning*

The basic requirements are:

(*a*) To have enough units to meet all requirements

(*b*) To have them in the right place at the right time

(*c*) A rapid recovery system to feed removed equipment into a cycle where it can be serviced, refitted, tested and made ready for re-issue.

*Numbers Required*

Initially, provisioning for Overhaul by Replacement must be based on the best estimate of the need, using whatever data may be available and relying on engineering judgement for the remainder. As experience is gained it should be possible to feed in facts about reliability and the modification procedure recently introduced can be used to increase performance. Eventually, a balance can be arrived at where there are enough, but not too many equipments to enable the policy to be effectively worked.

*Recovery of Worn Equipment*

This must be examined in the light of the following facts:-

(*a*) Equipment is becoming more complicated

(*b*) Rapid turn-round is essential

(*c*) Testing on completion is essential

(*d*) Modifications must be incorporated during repair

(*e*) A steady flow of spare components is essential.

*Complication*

Auxiliary machinery has now reached the stage where old-fashioned methods of refit are unsatisfactory. It is necessary to follow a laid-down overhaul procedure and such matters as cleanliness of lubricating systems and adjustment of clearances, though always important, are now quite vital. A certain amount of special training will be required for the men doing the job, plus some special equipment and all this argues strongly in favour of line overhaul.

*Speed of Repair*

The capital locked up in the machinery to form a complete overhaul by replacement policy will be considerable and every effort must be made to minimize the time for which machinery is unusable. In addition, it is well known that machinery awaiting refit tends to deteriorate still further and to be more

difficult and more costly to refit. The aim should be to get items into the refitting line as soon as they are removed from ships. Most machinery exchanged abroad should be returned to the United Kingdom for overhaul, unless the defects are trivial and the demand on station great. Some flexibility must be permitted here.

*Testing*

Replacement machinery, if it is to be of any use, must be fully serviceable and able to run immediately it is installed. To ensure this, testing of refitted machines is essential. Testing eliminates mistakes and ensures that machinery is capable of fulfilling its design function. It is necessary to use the fluid that is pumped by the pump when installed, but, apart from any operating requirements that D.M.E. may lay down, it is not necessary for the test system to conform to that in a ship, although the full pump performance must be obtained. Machinery other than pumps must be proved to full performance.

*Modifications*

A modification procedure is being introduced for machinery. This will produce a steady stream of changes to machinery, which can be incorporated in equipments during overhaul. It is vital to the success of this system that a proper check should be kept of the state of modification of each equipment. This is most easily done during line overhaul.

*Spares*

It is essential that replacement equipment should be able to use on-board spare gear, so it should be returned as 'As New' state at each overhaul. To do this will require a steady flow of spare gear from S.P.D.C., according to the programme. Again line overhaul assists this process.

Given all this and in combination with a reasonably enforced Systematic Machinery Selection Concept, Overhaul by Replacement at last becomes a really viable policy.

## CONCLUSIONS TO PARTS I, II AND III

It must be emphasized that this article appears in the non-official part of the *Journal*. Though it probably represents an accurate résumé of the thinking in D.M.E.'s directing staff this may still be a far cry from official policy.

There is no lack of goodwill but what seems crystal clear and entirely obvious to a marine engineer may conflict wholly with equally reasonable points of view held by other professional officers or with present financial or contractual policy.

Policy makers today are so often the prisoners of events; but also so often a framework of purpose is lacking. Bureaucracy goes on arguing until some crisis intervenes when dramatic decisions are taken and, once taken, become dogma in case the whole searing process of discussion may have to be undertaken once more.

Luckily today there is a great sense of common purpose concerning the need to solve the prime issues facing the Fleet—

How are availability and usage to be increased?

How can the administrative load on seagoers be reduced?

How can the Fleet be made more cost effective?

What is reported here has been widely discussed for nearly eighteen months and not only in the Directorate of Marine Engineering. This is D.M.E.'s 'framework of purpose'.

## PART IV

### A PERSONAL VIEW

What follows is different from what has gone before in that it is only an opinion of the authors of this article and has not yet been discussed outside a small circle—albeit this circle is not confined to D.M.E.

The last paragraphs of Dr. Kissinger's book *The Necessity for Choice* read as follows:-

> 'The deepest trouble of our time is probably the pedantic application of administrative norms. Its symbol is the "Commissar" the ideal type of bureaucrat, who condemns thousands without love or hatred, simply in pursuance of an abstract duty. But we would do ourselves an injustice if we ignored that the Commissar is not just a Soviet but a universal phenomenon—the communists have simply encouraged its most extreme form. He is the leader whose goals are defined by regulations in whose making he has had no part.
>
> This obsession with safety and predictability must produce an attitude fearful of risk. Our challenge is to overcome an atmosphere in which all sense of reverence for the unique and therefore the capacity for real innovation stands in danger of being lost'.

### Defence Policy in General

The making of defence policy has become, in the last twenty years, almost infinitely complicated. The range of problems that faces policy makers has become too wide and too varied for the sort of pragmatic opportunism by which we have, often so successfully, muddled through in the past. The simple fact of 'lead times' alone has taken defence administration into a new dimension. It is commonplace for the strategic climate that gave rise to the original operational requirement to have changed completely during the seven or eight years it takes to develop a weapon or an engine room from the conceptual to the operational stage.

### The Ship Department and the Ministry of Defence

Much criticism is often levelled at the Ship Department and some of it is just; this is also the easy way of excusing many other H.Q. failures. We are convinced that the true answer to the problem, the existence of which we all acknowledge, lies in something much wider and much deeper. Essentially most military problems of the sort we deal with are economic problems in the efficient allocation and use of resources. If this was more universally accepted we should get along faster.

The 'Control' mechanism in some areas is still not very sophisticated. We say this in no spirit of carping criticism; things are moving, albeit slowly, as always in our system of government. But for what it's worth it is our view that until we all occupy ourselves more with looking at maritime problems and how to go about solving them rather than with the substantive solutions themselves, which are in any event dependent on current circumstances and technologies and hence ephemeral, we shall not get very far.

With nuclear power, cybernetics, electronics and computers a subjective approach to our problems, hare-brained planning and superficiality must be very expensive and may cause irreparable harm. We believe that only a profound analytical basis for our decisions, only an assessment that takes into account all factors of reality, only an organization which determines that *all* essential questions will be asked, will fully insure that our tasks are properly met.

It is not original to say that today, when painful decisions are required, there is a tendency to duck into confusion. Very often people do not want ot be handicapped by hard, properly established, facts. This doesn't mean that decisions don't get taken, but they are often based on emotional conviction and prejudice. The role of systematic quantitative analysis in military decisions is potentially much more important than in the private sector of the economy. The quantitative relations may involve many different fields of technology as well as operational factors and the reactions of people (in our case sailors) and are often incredibly complex. Also in the private sector efficiency can be achieved by competition and natural selection which do not exist in Government. Instead, in our case, efficient techniques and policies have to be selected consciously and because the relevant factors are so diverse and complex, unaided intuition, on which in fact today we and the Naval Staff almost entirely rely, is incapable of weighing them and making a fully efficient decision.

We believe that until all the threads which control mobility, that is the reaction time, availability and usage of the Fleet, whether the threads are concerned with design, maintenance, dockyard support, logistics, operations or personnel, are brought together into one Systems Analysis office, which we christen a 'Directorate of Operational Technology', no dramatic improvement in mobility can be foreseen.

We visualize that this directorate must be capable not only of selecting appropriate criteria but also of establishing the facts concerning resources of manpower and money, and how best such resources can be deployed right across the whole field of naval responsibility, to meet the criteria chosen.

This idea is open to widespread misconstruction. We emphasize that it will not in any way cut across professional officers' responsibility for professional advice. But today some limitation in resources is inevitable. Out of this limitation of resources stems the need for systematic thought on the problem of getting the most out of them. Inevitably there is a necessity for choice. We need a small organization which can take professional advice and test it (for instance) against well established criteria.

Over the Systems Analysis office in the Pentagon there is said to be inscribed the words . . . 'It is better to be roughly right than exactly wrong'.

We, in D.M.E., have a lot to do in our own backyard. It seems as clear to us as to many others in the Directorate that if we continue with the old policies of tailoring our machinery to each new design we shall be 'exactly wrong'. If we can get the Systematic Machinery Selection Concept, and Refit by Replacement, or something very like them accepted, with all that both involve, we hold that inevitably we must be 'roughly right'. But again we in D.M.E. only deal with one small aspect—albeit a vital one—in the broad field of mobility. There is need for a wider application of Systems Analysis.