IMPACT OF MARKET FORCES ON SHIP UPKEEP STRATEGY

BY

R. N. SHIELD, B.Sc., A.C.G.I., C.ENG., M.R.Ae.S., F.B.I.M.
AND
D. S. MOON, M.Sc., A.C.G.I., C.ENG., M.I.MECH.E., R.C.N.C.
(Devonport Management Limited)

This article is an edited version of a paper presented at the Institute of Marine Engineers' Centenary Year Conference, 'Past, Present and Future Engineering in the Royal Navy', held at the Royal Naval Engineering College, Manadon, from 6th to 8th September 1989. It is printed here with the agreement of the Institute of Marine Engineers.

ABSTRACT

Commercial operation of Devonport Royal Dockyard since 1987 has been successful in improving value for money. The current policy needs to evolve in order to allow the Navy to realize the full benefits. Competitive tendering for batch (rather than single ship) refitting would encourage investment for greater cost-effectiveness. A new policy is proposed for integrating procurement and upkeep to provide a total warship service funded by the private sector and paid for by MOD on a contract basis.

Introduction

When DML (Devonport Management Ltd.) started its commercial operation in April 1987 it marked the end of nearly 300 years of state operation of Devonport Royal Dockyard.

The contribution of Naval Dockyards to industrial and economic development in the U.K. has been significant but, despite their well-earned place in history, they have been the source of criticism for as long as our generation can remember. The foundation for the criticism was simply that there was no practical way of assessing the value of a Dockyard's output and consequently the effectiveness of application and management of resources was a matter for subjective judgement by user, manager and observer.

The driving force of the current government with its vision of privatization and enterprise culture succeeded where many others had failed but, despite the battle cry of 'value for money', commercial operation was brought into being more on the basis of dogma than hard evidence of cost saving. It is therefore timely to assess the effectiveness of commercial operation and the procurement policy that accompanied it, and to examine the wider impact of market forces on warship capability, warship engineering and the warship industry.

The Past

The last horse was taken out of active use from Devonport Dockyard in 1960 during the period that a new COSAG frigate H.M.S. *Tartar* was under construction on the same site. H.M.S. *Scylla* was completed 20 years ago and was the last warship of around 300 ships built at Devonport in its 300 year history. Devonport has contributed very significantly to naval engineering over the last 150 years but its positive contribution was mainly in the early years.

The vision of our MOD predecessors in the middle of the 19th century was astounding in its depth and projection. Woolwich had supported the initial steam fleet but to meet the increasing demand Devonport was selected

to become a steam yard with Portsmouth and Malta to follow. The steam yards became the very foundation of naval engineering and Keyham Steam Yard (FIG. 1), which was completed in 1853, became the Mecca of naval engineering with the addition of the Keyham Naval Engineering College in 1880[1].

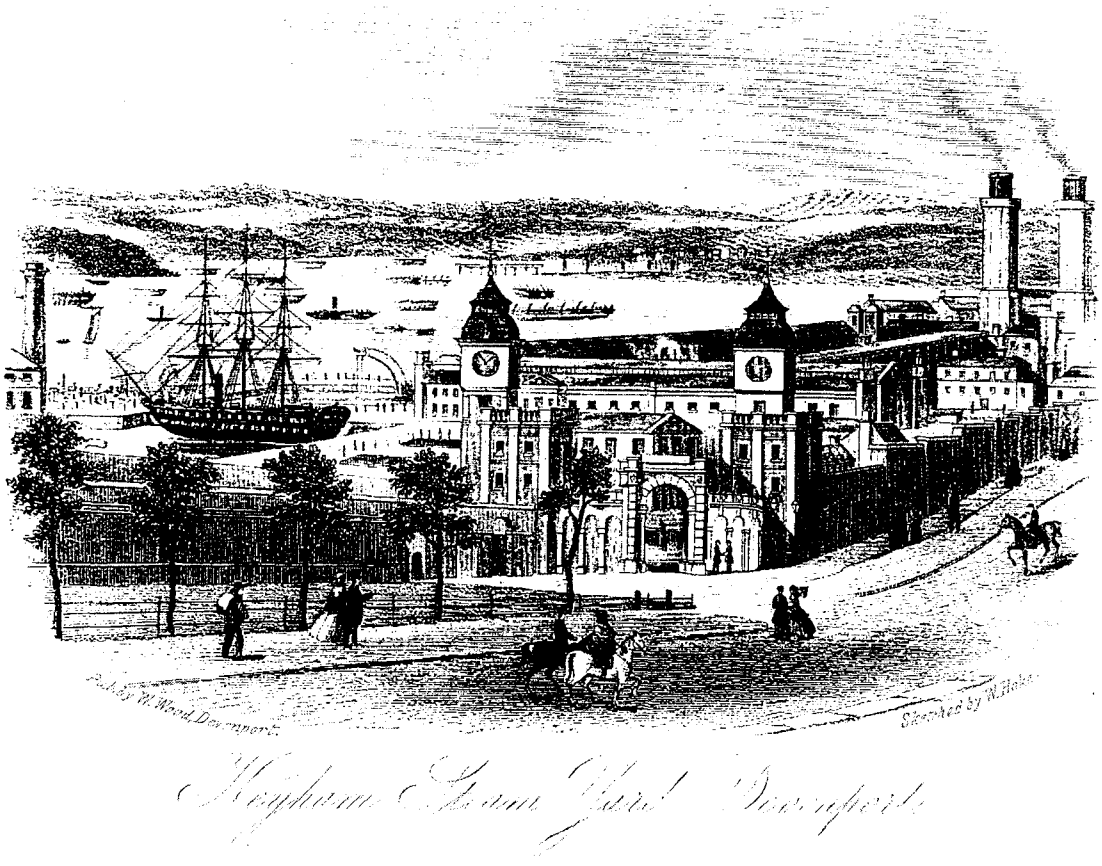

FIG. 1—KEYHAM STEAM YARD, AT DEVONPORT, BUILT BETWEEN 1846 AND 1853

The Keyham Steam Yard with its massive stonework offices, workshops, docks and berths integrated by sympathetic architecture was impressive by any standard but most impressive of all was the Engineering Factory which covered 10 acres and incorporated every facility necessary for maintaining or building warship machinery of the day. That the Factory or Quadrangle is still in use today, relatively unchanged, is a tribute to the vision of 19th century naval policy makers. It is also an example of the way in which Government-funded organizations influence progress. The time to build Keyham Steam Yard was seven years and the cost was three times the original estimate; the same performance was achieved for the Submarine Refit Complex (FIG. 2), completed in 1980.

While the size and durability of the 19th century project leave one in awe, the very size of the facility and its infrastructure tended to consolidate naval engineering rather than contribute to its development. The fact that the environment was never required to demonstrate a return allowed the sheer size and capability to be upheld and revered and to dictate naval engineering policy without question; the virtue of the initial vision which allowed the expansion of technology subsequently tended to inhibit development rather than encourage it.

The other influence which was consolidated during this period, and which like the architecture has stood the test of time, was the balance of perception and expectation of quality resulting from the absence of a trading relationship

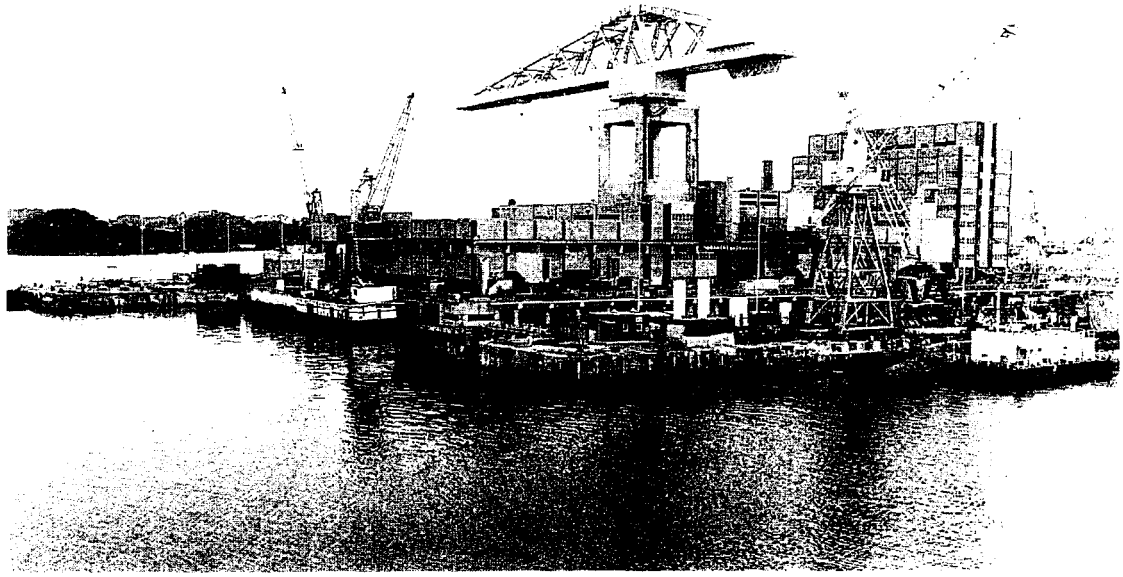

FIG. 2—THE SUBMARINE REFITTING COMPLEX, COMPLETED IN 1980, FOR 2 TO 3 STREAMS OF NUCLEAR SUBMARINES. IT HAS TWO BESPOKE DOCKS AND A HOLLOW CORE BUILT UP FROM THE SEA BED TO HOUSE THE NUCLEAR REFUELLING AND REFIT SUPPORT FACILITIES

between the Navy and the Dockyard. The standards of engineering were the subject of pride to the management and artisans and, because the service was available, the operators (the ships' staff) were reluctant to forgo the elegant solution in favour of a fit for purpose standard of quality.

The net effect was to create stability and confidence but with a tendency to inhibit progress.

Financial Management Before Commercialization

Expenditure for facilities, machinery and plant has always been controlled by external administration but the systems which evolved in a climate of reducing budgets were extremely clumsy and slow.

The parliamentary annual vote system for defence spending made it necessary to provide and justify long-term forecasts of cost on the basis of past practice rather than financial justification. The complex and lengthy procedure for procurement of major facilities which required the Dockyard to compete with other naval requirements for funds from a politically allocated budget, frequently led to project timescales spanning ten years between establishing the requirement and the availability of a facility (FIG. 3).

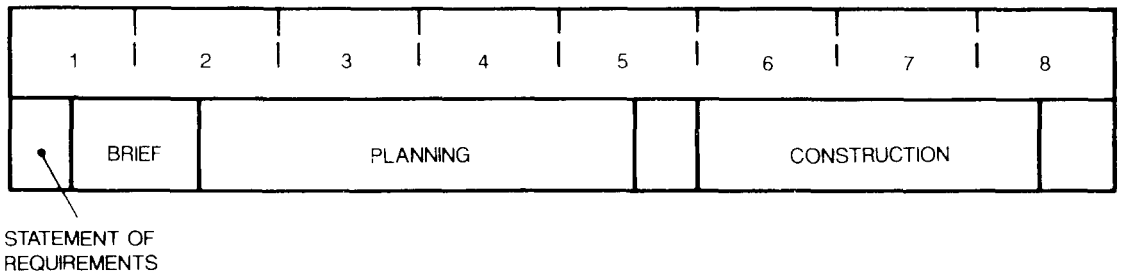

FIG. 3—A TYPICAL PROJECT TIMESCALE IN YEARS. THE PLANNED RATHER THAN ACTUAL TIMESCALE FOR A NEW LAGGING SHOP, CLASSIFIED AS CATEGORY 1 ('A PROJECT OF THE HIGHEST IMPORTANCE . . .')

Regrettable also is that the design of facilities was often centred upon information provided to flesh out the statement of requirement, after the original sponsor had moved to a new post.

However the heart of the problem was that financial appraisals for major facilities were generally based on savings in terms of current operating cost rather than a return on investment[2].

The Treasury had a somewhat more sophisticated method of comparing cost for alternative use of central funds but even then it was not required to demonstrate a commercially realistic return on investment[2].

The Frigate Refitting Complex[3] (FIGS. 4, 5 and 6) at Devonport was one of the more adventurous and well thought through projects but, although it was justified by setting cost against notional savings to the Navy, the savings could not be realized, the Dockyard saw only increased costs and the Treasury had no return on their investment[4].

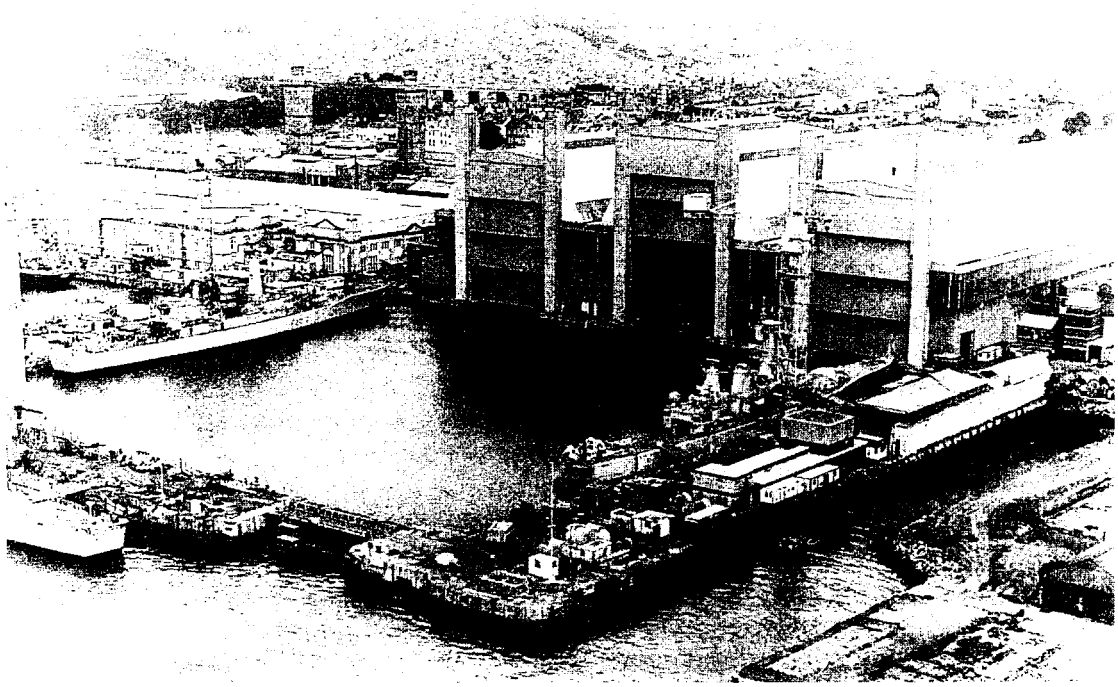

FIG. 4—THE FRIGATE REFITTING COMPLEX, COMPLETED IN 1977, DWARFING THE TEN ACRE ENGINEERING FACTORY BUILT 125 YEARS EARLIER

Acquisition of machine tools and plant followed a similar, though generally slightly shorter procedure, and often resulted in machines arriving when the circumstances that justified the requirement had disappeared. Further, the inability of the accounting system to provide a meaningful cost for many operations led to machinery being kept in service even though rarely used.

Lack of commercial accounting also influenced working practices and management. The method of working was to assume that the craftsman understood what was needed to satisfy the customer and, in the absence of any kind of customer/supplier relationship, the customer had no incentive to seek improved value for money since savings could not be realized. The customer therefore tended to ensure that the previous standards that prevailed were preserved and that meant spending all of the resource budget allocated to the refit; it goes without saying that the resource budget was based principally on historic data.

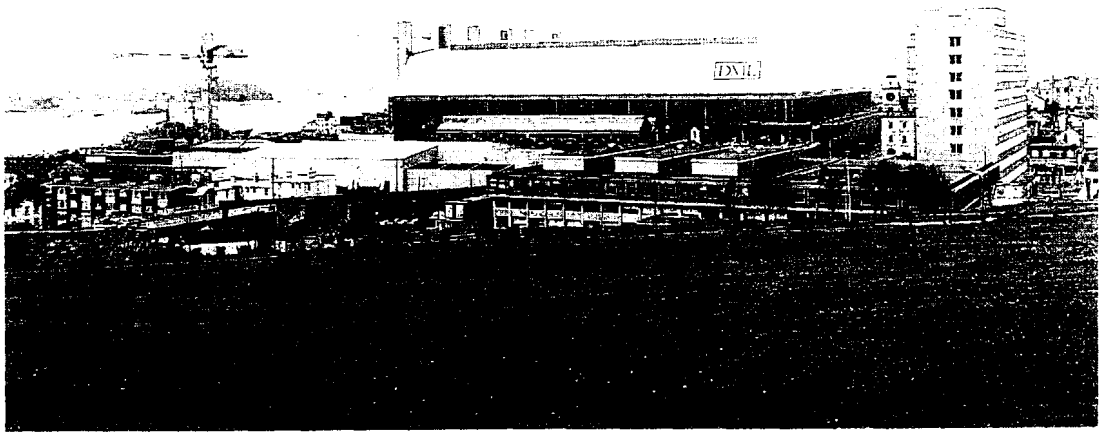

FIG. 5—ANOTHER VIEW OF THE FRIGATE REFITTING COMPLEX

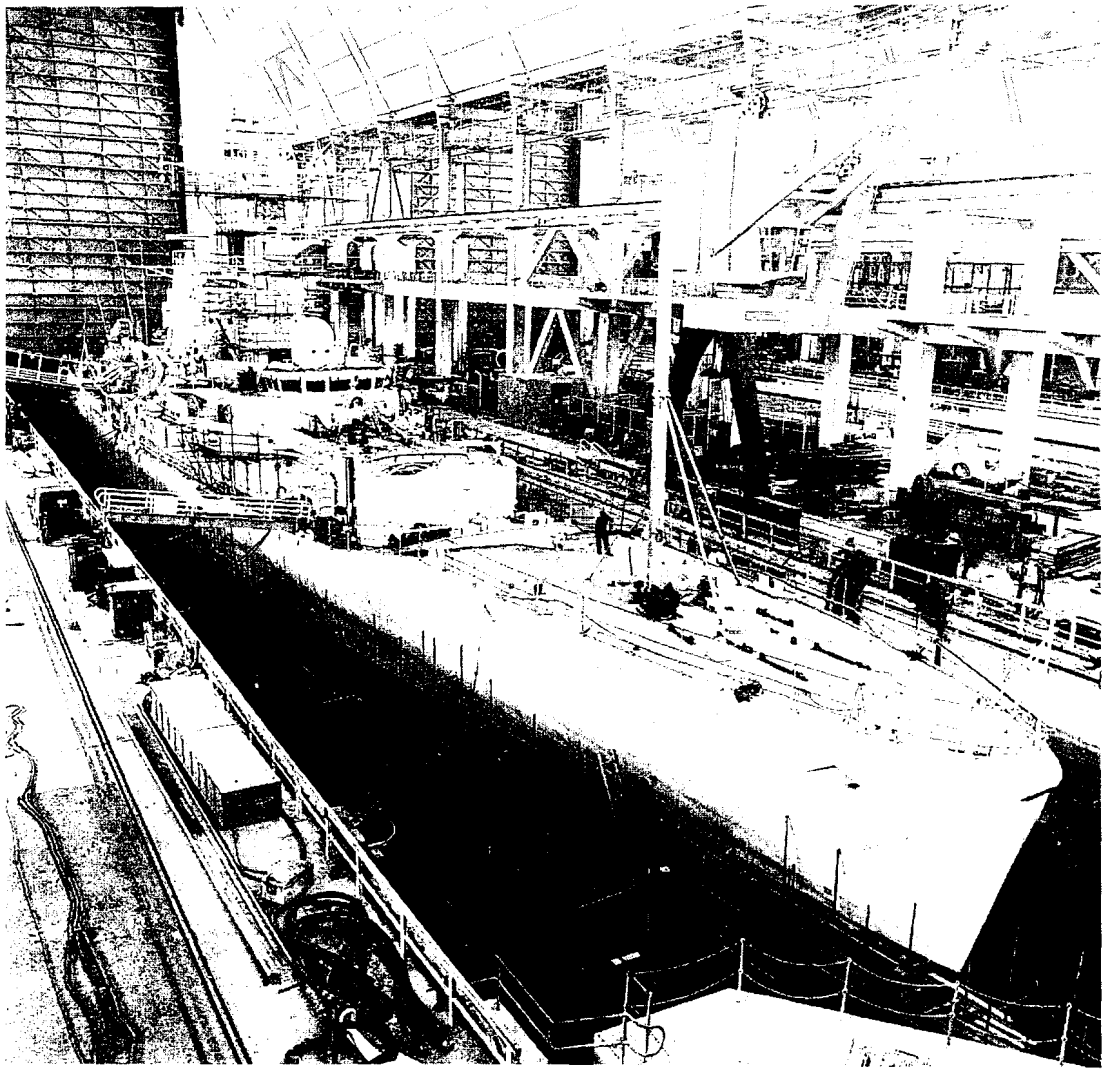

FIG. 6—A 'LEANDER' CLASS FRIGATE, AROUND WHICH THE FRIGATE REFITTING COMPLEX WAS DESIGNED, UNDERGOING ONE OF THE FIRST UNDER COVER REFITS THERE

Most attempts to introduce pay-related productivity schemes failed because the motivating forces were not harnessed to cost reduction through improved methods, mechanization and innovation but to improved output/man in isolation. The absence of commercial pressures to make effective use of resources and investments led to today's method being consolidated into tomorrow's capabilities.

In the run-up to commercial management, interim measures were introduced to reduce cost but this concentrated on improved control of manpower performance against existing practices rather than overall improvement in output per pound spent. Innovation and improvement were not addressed or allocated very low priority; even the production facility and method engineering group was taken out as a cost-saving measure.

In the post-war years, as the defence budge declined, the grand facilities aged and administrative systems spread their tentacles. The influence of Devonport on naval engineering declined and at best the Dockyard reacted to developments rather than contributing and at worst it slowed them down. In the early 1980s through-life maintenance of a warship was estimated to be nearly a third of the life cycle cost of a warship (FIG. 7).

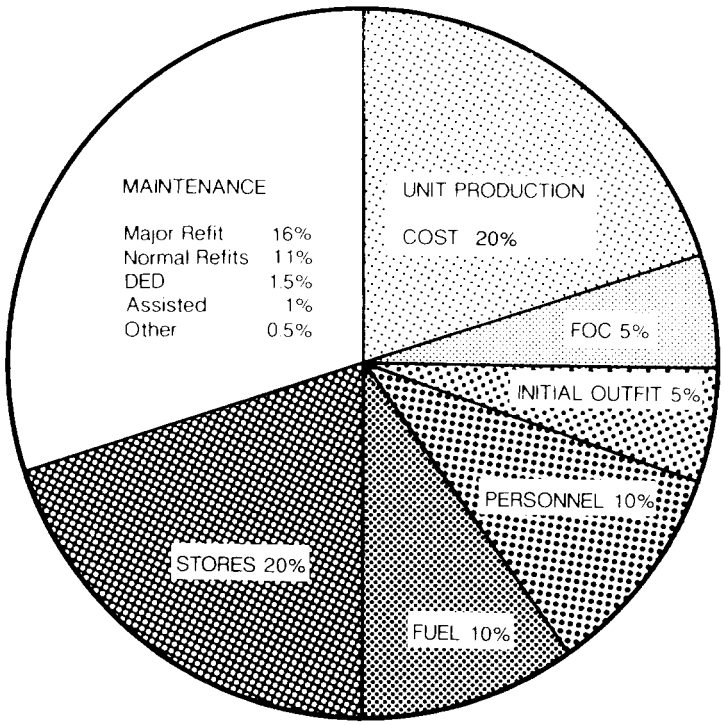

FIG. 7—TYPICAL LIFE-CYCLE COST OF A FRIGATE
FOC: SHARE OF FIRST OF CLASS ADDITIONAL COST
INFRASTRUCTURE AND R & D COSTS NOT INCLUDED

The shortcomings that prevailed were not the result of lack of commitment, leadership or management skills on the part of the parties involved. They were the effect of policies designed to administer expenditure of public funds, rather than to show a return on investment.

When circumstances needed swift action to achieve strategic requirements, the results were startling, e.g. the Polaris Programme and the South Atlantic Campaign. However, successes of this nature demonstrate effectiveness but not necessarily value for money, let alone viable commercial business. The time was ripe for a major initiative.

The Advent of Commercial Operation

A system was required that, as a rule rather than an exception, allowed policy and management to pull in the same direction, against real limiting factors rather than contrived restraints. For the past 20 or 30 years senior management of the Dockyard, during their brief postings, had cried out for the chance to manage rather than act as glorified watchkeepers operating an enormous administrative machine. They were not alone, for all interested parties have sought a way of allowing Dockyards to operate efficiently as well as effectively.

Numerous reviews and studies were carried out, the first major report being that of the Mallabar Committee in 1971, followed by five others, the last[5] being that of the special advisor to the Secretary of State for Defence and now the Chief of the Procurement Executive, Sir Peter Levene.

While all of the reports proposed different solutions, each had a number of common requirements:

- improved accountability and financial control;
- increased freedom of management with maximum delegation of responsibility from MOD;
- a clearly identified customer/supplier relationship.

Lack of clarity in benefits and mode of operation generally provided opponents to the report with sufficient ammunition to slow down or even stop the recommendations being implemented. Even the Auditor General's report of the early 1980s noted that 'one of the recent (Dockyard) reports commented that no-one who has waded in sequence through various reports on Dockyard organisation produced since 1971 can fail to be struck by the disparity between effort applied and results achieved.'[6]

However, the Government was getting restless and, stirred by the Public Accounts Committee (PAC) in 1984[7] the Secretary of State decided that action would be taken as soon as a suitable formula could be found.

The Levene report provided just that formula. It set down clear and simple proposals embodying the previous common requirements but differing sufficiently from previous recommendations to enable it to break through the well-exercised regiment of indifference and opposition. The proposal allowed for commercial management of each of the two Dockyards by a private company while the ownership of assets was retained by the MOD.

The Levene recommendation was pushed through energetically and effectively, some would say in cavalier fashion, by the Secretary of State against the usual myriad of cautionary advice, outright objection, political skulduggery and devious intrigues. This required leadership of a very different kind from that of the policy makers who decided to go ahead with the Steam Yards but its effect on the Dockyards is likely to be equally dramatic and its long-term influence on naval engineering philosophy even greater. Preparations for changing the future operations of the Dockyards, became confused with peripheral issues but the skilful use of a Public Relations programme to dominate and control the timing ensured that everybody kept their eye on the ball and did not allow any of the other issues to create a diversion or major obstacle. The date was held.

The competition to operate Devonport Dockyard was won by DML, a new company formed specifically for the purpose. DML is backed by a consortium of Brown and Root (UK) Ltd, Balfour Beatty, and The Weir Group PLC, who all hold equal share capital, with Barclays de Zoete Wedd holding 10% of the share capital in a discretionary trust.

On 6th April 1987 DML assumed full control of the Dockyard and from that day and for the first time in its 300 years of history, Devonport was being funded by its own working capital.

The anticipated period of 'parallel running', to allow both the Company and the customer's agent, the Director General Ship Refitting (DGSR), to establish and understand their relationships and ground rules, had to be foregone and this undoubtedly slowed the initial rate of progress in achieving the benefits of commercial operation. The one relief, however, was that full commercial operation had been introduced rather than a potentially disastrous halfway house. That is not to say that some manacles were not left in place, and have yet to be shaken off.

Initial Effects of Commercial Operation.

This is not intended as a report on the operation of DML but as a brief indication of the effectiveness of the commercial operation policy over the first two years. Any attempt at a precise comparison of performance at this stage would serve no useful purpose since no two refits are the same, there is no overall standard measure of output, and no identical accounting system for project costs. Indeed effective comparison even eluded MOD's own controlled exercise which involved carrying out refits of a submarine and a frigate in commercial shipyards in parallel with similar vessels in Naval Dockyards[8].

In general terms it is sufficient to say that the number of employees has been reduced significantly more than the decline in volume of warship refitting workload, that the real cost of refitting warships is decreasing, that reduction in time in hand exceeds MOD's expectations and that defined quality is being achieved.

However, it is necessary to examine more specifically the main influences of commercial operation and the impact they are making.
The main influences are:

- The requirement for a specific contract for each project.
- The need to account for all resources used.
- The need to make cost effective use of assets.
- The transfer of financial risk from MOD to the Company.
- The need to compete.

The Requirement for a Contract

The straightforward discipline of preparing a bid and negotiating a contract has merely added an extra overhead to both the supplier and the customer. The real benefit is the need to have a sound specification as the basis for a contract.

The specification has led to significantly tighter quality and cost control. The Company has been driven by a need to avoid overwork and rework to control cost, and the customer has been provided with a sound basis for acceptance and for gauging value.

To achieve the desired result a complete overhaul of the Dockyard organization and management structure was necessary to dismantle the established matrix and replace it with a focused project management structure. To support restructuring and reap the benefit of commercial operation required the design and installation of a full suite of IT-based systems and considerable development of an inherited, but new, purpose-built management accounting system. The whole package of change has been backed up by a significant on-going programme of education to engender a total commitment to quality throughout the workforce.

The level of detail in many specifications has been overdone although this has to a large extent resulted from the desire to identify what is being paid for in non-competitive contracts. On the benefit side to the Company, while it may be tedious to have a very detailed specification imposed, it is serving

as a lever for cultural change and for building up a useful data bank. A further long term beneficial effect is speeding the rate of progress in the use of IT to handle the vast amount of information that has to be processed (26 volumes of refit specification for a single submarine refit project replace the work package used before commercial operation).

It is quite likely that specifications will simplify as more of the projects are subject to pure competitive tendering, but the reduction in contract specification detail will only be replaced with planning detail for production engineering systems currently being implemented to achieve precision in control.

This trend to precision in control, to aid quality and repeatability, through wide use of IT will continue to increase its influence on the production process and in due course give confidence to designers that they will get what is specified and so allow a reduction in uncertainty safeguards and margins.

The Need to Account for All Resources Used

The need to minimize cost and therefore account for all resources to achieve a specified work item is making real cost more visible. Numerous improvements in the allocation of non-labour costs, the introduction of timesheet recording for overhead staff, improved accuracy of work recording and wide use of direct project charging for non-industrial services has channelled costs into being recovered where they are incurred.

The main benefits arising from improved visibility of cost are:

- identifying priorities for budget trade-offs;
- pointing the Company to where new methods are required;
- in the longer term pointing out to the procurement teams and designers the target areas for minimizing through-life costs.

Cost-Effective Use of Assets

Effective management of facilities is severely limited as the fixed assets are leased rather than owned, but the freedom which does exist can be exercised through the simple discipline of local financial and cost decisions.

Thus a large CNC machine tool was purchased for a specific contract, installed and put into use in 10 weeks, a process which would have taken a minimum of three years before commercial operation.

A further example is the extension to one dock of the Frigate Complex, to allow its utilization to be significantly improved. It was only because of the Company's declared intention to go it alone on the basis of its own investment appraisal (FIG. 8) that allowed the minimum year cycle time to be broken. The extension will be complete only one and a half years after the need was established.

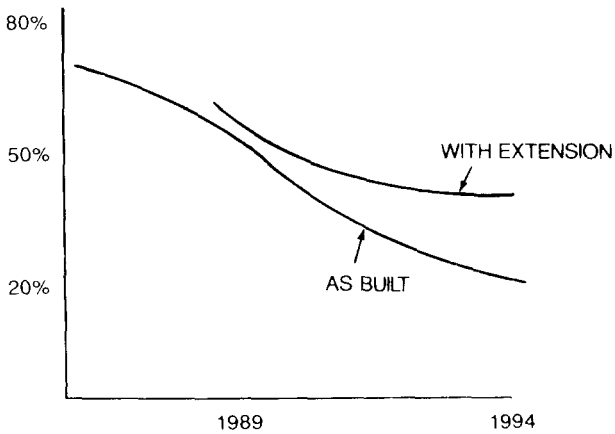

FIG. 8—FRIGATE REFITTING COMPLEX UTILIZATION. COMMERCIAL PRESSURE HAS RESULTED IN A DOCK EXTENSION INCREASING UTILIZATION OF THE COMPLEX BY 30%

The capability for rapid provision of cost-effective facilities is creating a future that overcomes today's limitations. It demonstrates to the designer and policymakers that:

- non-availability of support capability and facilities is not a restraint, even in the short term;
- the need for facilities can be accurately costed into engineering strategies.

Transfer of Financial Risks from Government to Contractor

The main reason published for using competitive procurement with the contractor bearing the risk is to ensure that MOD obtains value for money. There is another reason, not totally unconnected but covering a larger timsecale, the basic economic need for wealth creation.

The cost plus profit era of defence procurement stultified the wealth creation process and slowed technical innovation, industrial development and economic growth in those areas in which it was used.

The Government's stated policy is:

> A 'hands off' customer: our contractors should bear the full responsibility for the successful completion of their contracts, while keeping the Ministry informed of progress as necessary. Carrying risk, they should have the opportunity for reward if they are successful and efficient in delivering to time, cost and specification.[9]

Regrettably though, during the transition period the application of the government's quoted principle has been heavily biased such that all improvements on MOD(N) contracts benefit the customer (in short-term savings) and failures penalize the company and its growth prospects.

In the longer term some of these difficulties will diminish but the underlying problem will not disappear until a policy is devised that rewards or at least shares equitably the benefits of innovation and venturing. This will need longer term contracts in which benefits, both to the customer and contractor, are carried forward and adequate returns are potentially available for carrying the risk and the investment.

The Need to Compete

The essence of sound procurement must be competition. Undoubtedly it has been competition that has been the driving force behind prosperity of the developed nations.

The forecast work programme for Devonport is increasingly more exposed to competition as well as decreasing in value and volume. It is therefore a cornerstone of DML Long Term Strategy to:

- Win the maximum possible share of the warship refitting programme.
- Win other work to replace the diminishing naval workload.

Those two simple aims present a number of different problems and the solutions are paradigms of today and tomorrow's industrial business culture.

To compete for a major warship project should be relatively straightforward in that the Company's infrastructure and cost have evolved for core business. Competitive pricing should therefore reduce to a problem of balancing margin against risk. However the real problem that has to be faced is the significant difference in cost between companies with modern and/or well-maintained facilities and a reasonably full order book competing against an undernourished and over capacity industry where wealth creation has ceased to be a criteria and survival is dominant.

The only way to compete and win is to reflect the competition and establish a low-cost operation which carries only the overheads necessary in the survival mode using a large content of sub-contract labour; there is no scope for investment for the future. In the survival mode, the Company uses mainly sub-contract labour and services for much of the unskilled and low tech work content.

Another significant competitive scenario is competing for opportunities in the new markets using production capabilities that exist to support refit projects. In this case the survival mode of operation is replaced by a strategy which establishes stand-alone business units under the DML corporate umbrella.

To allow these business units the management freedom to develop, to compete and grow in new markets, requires each unit to operate to a comprehensive business plan which demonstrates an acceptable return on the notional capital employed. By virtue of the drive to be competitive in the new market the autonomous business unit will almost certainly provide a more competitive service with better 'value for money' to major ship projects, but it may find shipwork commercially unattractive.

The competitive influence is on one hand producing short-term cost savings which are neither sustainable or economically stimulating, and on the other creating a new breed of smaller well-focused support industries. The question which must be posed is whether the naval procurement policy is sufficiently well directed to achieve the optimum balance in terms of long-term value for money.

In summary it is clear that the commercial operating policy is successful in that it is achieving improved quality and lower cost for warship refitting, but it is not creating conditions for investment.

The Trend for the Future

Short Term

In the intermediate term we can expect cost to be forced down further by increased exposure of the refit programme to competition. The word forced was carefully chosen since the continued application of the existing policy, without refinements will result in contractors moving into the survival mode rather than endeavouring to engineer cost down.

In parallel with increased competition, the volume and value of work will continue to decrease as a result of increased visibility of costs, higher productivity and the lower direct work content in the upkeep of modern warships.

The policy of seeking increased up front investment by industry in the development of equipment will encourage manufacturers to provide through-life support which in turn will lead to an increased amount of work being returned to manufacturers or specialists during ship refits rather than being overhauled in place or in shipyard workshops.

The net effect will result in:

- Increased size of support structure for the customer organization to enable the more widely dispersed programme to be overseen and controlled.
- A decreasing business base for the major ship repairers.

It has been argued that to achieve timely completion of projects and effective use of resources, a single major warship refit project should not exceed more then 30% to 40% of a single shipyard's workload. With some projects valued at £80 m over two years and a total naval refit programme of £450 m/year there is not room for more than three or four ship repair contractors, a structure that may look attractive to the MOD.

However, such a relationship will not be generated by the current policy of full competition for individual projects, and it is therefore expected that the policy will be modified to accommodate batches of refits (a class of ship for a number of years) being offered to competition. Such a policy would allow the customer organization to simplify specifications and encourage investment on the part of the contractor to improve methods. It is significant that the cost justification for the Frigate Refitting Complex was made on the basis of streaming or batching frigates in the Devonport Programme.

The use of batch tendering for refits will allow the prime contractor to use sub-contractors more competitively and encourage innovation by sub-contractors to secure follow-on contracts as well as improving their return.

Batch tendering will also allow contractors to develop infrastructure support which in turn will allow the customer to simplify the refit specification. The ultimate specification would merely state the capability required, from a refit, in terms of availability and performance.

Such a policy would place upkeep management in the hands of the contractor, allowing a simplified customer organization, and provide a greater degree of commitment by the contractor with an incentive to innovate and invest. The downward spiral to operating in the non-wealth-creating survival mode would therefore be averted.

Longer Term Trends

While batch ordering with cardinal point specification will lead to sustained improvement in value for money in refits and upkeep, the full potential for savings is still not realized unless ships are engineered and designed to take advantage of the new policy. To really benefit it is essential that the industry can take advantage of the developments in technology arising from competition in larger markets.

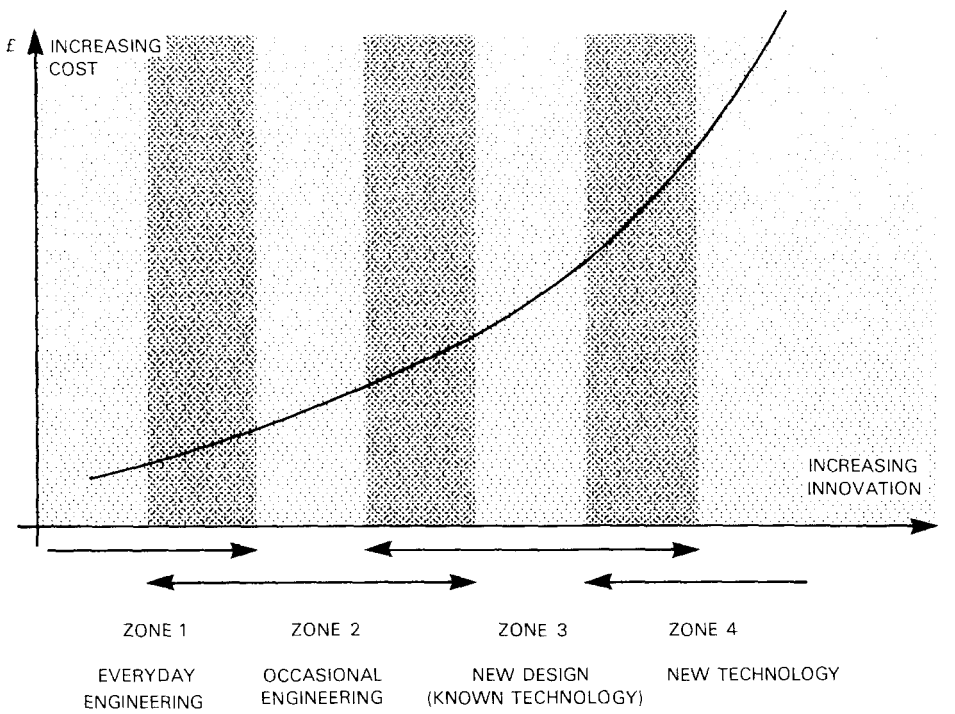

FIG. 9—COST V. DEGREE OF INNOVATION

M. B. Hawke, in his article on 'Warship Design for Economic Procurement'[10] describes how engineering costs are related to development and unit costs rapidly reduce with application in a wider market (see FIG. 9). To achieve value for money it is necessary for warships and naval engineering to move down from original engineering to a zone in which the technology is well developed and well tried.

That high unit cost can be driven down by competition is simply illustrated by Nolan and Taylor[11] where it is explained that the reason why dense graphics displays are available is not because of defence needs but because of the amusement arcade game industry.

So how can the Navy and MOD realize the full benefit of technological development through market forces operating in ship management and repair?

Future Policy

At this stage the scope of the discussion needs to be widened from warship upkeep to embrace total procurement.

The Navy requires lower through-life cost and an assured capability with up-to-date weapon systems. It means that unit and upkeep cost must be minimized but optimized to provide high availability, reliability and adaptability. To achieve these currently elusive through not mutually exclusive attributes requires the shipbuilder's commitment to continue throughout the operational life of the ship, and this in turn requires a procurement policy that leads to a beneficial integration of the new construction and upkeep industries and accelerated evolution of a total warship support service.

The immediate question that springs to mind is what features of a procurement policy, other than survival, will encourage the Government and industry to pull in the same direction?

A simple examination reveals that on one hand the Government is seeking privatization of state industries, contractorization of government services, up front funding for defence equipment, and encouraging enterprise and innovation through small businesses, while on the other industry and commerce are seeking investment opportunities with realistic returns.

It is therefore postulated that ships should be procured as a total service to provide the Navy with a specified capability on a cardinal point basis. The concept requires a competing consortium of contractors to bid to provide a number of operational days of capability per year for a number of years. The consortium would be expected to fund the provision of the ships and upkeep with reimbursement against days of operational capability provided to the Navy. A number of consortia could be expected to compete for the various blocks of capability for which MOD seeks tenders, knowing that they are competing for investment opportunities rather than short-term profit or even mere survival.

The winning investor or consortium will build, buy and even convert ships which it knows that it has to maintain at its own expense and which it knows that it will need to modify and update if it is to win further blocks of operational days.

The shape of the industry to emerge from such a policy is likely to be consortia with a strong corporate technical and infrastructure support organization drawing upon a wide range of horizontally integrated sub-contractors. The industry's main strengths will be integrated information and logistic support together with a strong element of corporate venturing to make optimal use of sub-contractors and technical developments and to create and develop the supporting industrial infrastructure. The extensive use of sub-contractors will allow it to take advantage of up-to-date technology and its commercial applications, while the size and continuity of the operation will allow the consortium to trade effectively and influentially with major corporations and industries.

The structure of the industry is also likely to encourage cross-border collaboration and to speed the much-needed[12] rationalization of parts of the European defence industrial base.

Operation of the policy

At this level of exploration it is not intended to examine the concept in any financial detail, but in broad terms MOD could be expected to offer blocks of operating days of value not less than £1bn and not exceeding £3bn, over periods of five to seven years. However, this would not preclude a specific consortium winning staggered blocks of the same or concurrent blocks to different performance specifications.

Providing the funds for each block is probably the least of the probler in getting the scheme up and running, but it is most likely that the Governme would insist that all investment should be private and mainly from U.I investment institutions.

From the Navy's point of view the cost of an operational day for frigat and destroyers would be in the region of, say £150k (excluding consumab stores and personnel) a figure which if posted on the ship's board wou focus attention on the need to achieve operational effectiveness as much more than price tagging service stores[9].

It has been suggested that ships could be built and leased to the Navy varying rates dependent upon their operational condition and age, as well capability[13] but it may be more appropriate for the Navy to demand ope ational effectiveness and thereby keep the policy market driven rather tha lapsing into a supply driven situation.

The scope of the policy need not be limited to provision of the ship ar upkeep, and could possibly be extended to victualling, ordnance, blue wat support and weapon systems R & D but at present application in these are has not been examined.

Superficially it may appear that the Navy is being asked to turn full circ back to the Tudor days when powerful and wealthy barons provided the own ships to serve the King's and Country's cause. In reality the Navy an MOD are being strengthened professionally by demanding service witho becoming embroiled in detail thus allowing them to concentrate on their co task.

Conclusions

Upkeep of ships has influenced naval engineering ever since the introductic of the steam yards in the mid 19th century, but with state funding controlle by artificial restraints the initial benefits of vision and major investment we turned from a driving to a trailing influence in that today's practices we consolidated into tomorrow's capabilities.

The introduction of commercial operation of the Dockyards was aimed using market forces to improve value for money in warship upkeep, an after two years it is proving to be successful, at least with DML at Devonpor

The continued application of the current policy in an ageing over-capaci industry will have little beneficial influence on the advancement of nav engineering and is unlikely to allow MOD or the Navy to realise the ful benefits of commercial operation.

It is likely that the current policy will evolve to cover competitive tenderir for batch contracts and encourage a closer relationship between ship procur ment and upkeep, possibly leading to industrial alliance or mergers.

To realize the full benefits of commercial pressures and market forces, new policy is proposed for integrating procurement and upkeep to provide total warship capability service funded by the private sector and paid for b the MOD as a contract service for an operational usage basis. The policy aimed at encouraging innovation and investment as well as cross-fertilizatio between developments in naval engineering and industrial technology.

Strategic use of market forces and commercial pressures could ensure th survival of the warship industry and promote innovation in naval engineerin

Acknowledgements

The authors wish to thank DML for permission to publish this paper ar the support they have afforded in its preparation. They would also like thank colleagues in MOD and DML for assistance and advice.

References

1. Dicker, G.: *A short history of Devonport Royal Dockyard*; Devonport Naval Base, [1968?].
2. H.M. Treasury; *Investment appraisal in the public sector—a guide for government departments*; H.M.S.O., 1984 (ISBN 0 94 781902 9)
3. Cribb, M.:. the Devonport Frigate Complex; *Journal of Naval Engineering*, vol. 22, no. 1, Dec. 1974, pp. 101–112.
4. Boarer, A. C. and Prior, J. B.: The Devonport Frigate Complex; *Trans. Royal Institution of Naval Architects*, vol. 122, 1980, pp. 505–521.
5. Debate on Royal Dockyards; *Hansard*, 17 April 1985.
6. *Comptroller and Auditor General's Report, Control of Dockyard Operations and Manpower*; H.M.S.O., 1983.
7. Committee of Public Accounts: Control of dockyard operation and manpower: Ministry of Defence; *22nd Report of Session 1983–84* [House of Commons Paper 342]
8. Ministry of Defence: Submarine Compex report, June 1988.
9. *Statement on Defence Estimates 1987—Equipping the Armed Forces*, vol. 1, section 5; H.M.S.O.
10. Hawke, M. B.: Warship design for economic procurement; *Journal of Naval Engineering*, vol. 31, no. 1, June 1988, pp. 1–12.
11. Nolan, D. B. and Taylor, L. A.: An overall combat system approach; *Journal of Naval Engineering*, vol. 30, no. 2, June 1987, pp. 255–259.
12. Van de Muyzenberg, L. and Spickernall, G.: Restructuring in the defence industry; H. B. Maynard Research Report, 1989.
13. Hill, R. C. F.: Achieving cost effective warships; Royal College of Defence Studies paper, 1985.